THE

AUTOMOBILE HANDBOOK

A WORK OF PRACTICAL INFORMATION FOR THE USE OF

OWNERS, OPERATORS, AUTOMOBILE MECHANICS AND TECHNICAL SCHOOLS

By L. ELLIOTT BROOKES

New Edition Revised and Enlarged

By CALVIN F. SHINGLE, M. E.

And Other Experts

A strictly up-to-date treatise, dealing in a practical manner with all the various questions relating to the construction, care and operation of gasoline, electric, and steam automobiles, including illustrated descriptions of the many different parts, together with clear and concise explanations of the principles governing their action. Correct methods are given for dealing with

ROAD TROUBLES, MOTOR TROUBLES, CARBURETOR TROUBLES and IGNITION TROUBLES

Also valuable information pertaining to ignitation systems, carburetors, magnetos etc., etc. Valve setting is dealt with in detail, also indicator work, with numerous tables, useful rules and formulas, and over three hundred illustrations.

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INTRODUCTION

Progress in the automobile industry in the United States during the past ten years has been phenomenal. The mechanical propulsion of a wheeled vehicle along an ordinary road is not by any means a new idea. History tells us that speculations upon the possible road use of "fire, and steam engines" were made by Roger Bacon (1214-1294), and in the year 1619 a patent was granted in England to Ramsay, which had as a part of its subject "drawing carts without horses." Many attempts were made from that time on to perfect a self-propelling road vehicle, using steam as the propelling force, but it was not until the end of the year 1883 that Delamare-Debouttville constructed what is thought to be the first gas tricycle which actually ran on a public road. The general employment of gasoline motors is due to two Frenchmen, Levassor, and Panhard, who in 1889 exhibited in Paris a tram car having a Daimler motor. Since then the development of the gasoline motor car has been remarkable, due no doubt to the fact that some of the best engineering talent in the world has been, and is at present being directed toward the perfection of the various types of automobiles, and it is entirely within the bounds of reason to expect that a machine requiring so high a grade of talent for its design and construction, should in its operation be under the care of a skilled and reliable chauffeur, one who not only understands the principles of operation of each and all of the various parts which go to make up the whole, but who also is competent in case of minor accidents on the road, to make such repairs as will enable him to proceed. He also should be able to make such adjustments, and give the machine such care as to reduce the expense of maintenance to a minimum. It is with a view of assisting owners and drivers of automobiles, in fact all who are in any way interested in a study of this remarkable, and at the same time most useful machine, that the Automobile Hand Book has been rewritten and revised, thus bringing it strictly up to date, and in touch with modern practice in the art of automobiling. While a

considerable portion of the subject matter found in former editions of the book has been retained for the reason that it is standard, by far the larger portion of the volume is new matter, and embodies the most recent improvements in automobiles, together with instructions concerning their care and operation. Each part of the machine is thoroughly treated upon, and its construction and the principles governing its operation are explained and illustrated in detail. While the gasoline motor with its various accessories naturally occupies the major portion of the book, still a considerable space is devoted to steam, and electric motor cars. Special attention is given to ignition mechanism including the various types of carbureters, magnetos, etc., all being clearly described and illustrated. Transmission apparatus of all kinds is dealt with in detail. Wheel construction receives a large share of attention, and the important subject of tires is freely discussed.

A large space is given to repair work in the shop, and garage. As the subject of state license laws contemplating the appearance of the chauffeur before an examining board is one in which all motorists are vitally interested, this book will prove to be a reliable and trustworthy guide to all persons taking such examinations.

Note—The author gratefully acknowledges his indebtedness to the following named gentlemen, consulting engineers, and authors of standard works on engineering subjects:

Oscar C. Schmidt, consulting editor American Text Book Co., author of Practical Treatise on Automobiles.

Paul N. Hasluck, author of Construction of Modern Motor Cars.

The International Text Book Company, Scranton.

The Automobile Handbook

Acetylene. A number of inconveniences are attached to the use of acetylene. The problem of properly purifying it has yet to be solved. Metallic compounds of sulphur, phosphorus and nitrogen and free carbon are contained in the carbide, and the gas has in it many impurities which endanger health when burned in closed rooms. The free carbon in the carbide gets into the burners in the form of fine dust and obstructs them. A great annoyance is smoking of the lamps, which takes place after two or three hours burning. This is due to decomposition of the acetylene by the heated burner, by which carbon is deposited in the narrow opening. Many of the so-called spontaneous explosions of this gas have without doubt been caused by high temperature in the generator.

Acetylene Lamp System—Care of. As there is little night running during the winter months, the acetylene lighting system is more or less neglected, the generator being left with stale or partially used carbide in the chamber, and the residue being allowed to clog up the water port and the waste ports. The rubber

lamp connections and gas-bag suffer also by deterioration as well as the burners and gas valves. For the proper maintenance of the system, strict cleanliness should be maintained at all times, and the various parts should be examined and replaced from time to time as necessary. The results of neglect are seen every spring in lime deposits which have to be removed by means of a cold chisel, in porous connections and in clogged burners which resist the cleaning wire and necessitate the scraping of the burners. By following the accompanying directions, the automobilist can depend on having his lighting system in good shape whenever he desires to use it.

Acid Solutions. The electrolyte, or solution used in storage battery cells, is made by pouring sulphuric acid into distilled water until the specific gravity becomes 1.12. The solution becomes extremely warm and should not be used until its temperature is about 60 degrees.

Accumulators. The accumulator or storage battery is the only source of electrical energy of practical use for driving an automobile, because an electrically propelled car, like other automobiles, must self-contain its supply of energy, and thus it excludes employment of the trolley running under a conductor in constant communication with generators at the power station.

The accumulators used in electric automobiles are adaptations of the storage batteries used for

electric lighting, but are much lighter and give a greater output, weight for weight; they are also made to bear over-discharge, and the wear and tear of rough travelling. The active agents in general use are lead and dilute sulphuric acid.

Accumulators may be divided broadly into two classes; namely, the "to-be-formed," or Planté kind (1873); and the "pasted," or formed Faure kind (1881). The object of both processes is to produce a couple consisting of a positive electrode of lead oxide, and a negative electrode of lead in a solution of sulphuric acid and water. Peroxide of lead is formed on the positive, and pure lead on the negative, by the process of charging; and energy is stored which is given up on discharging the battery, when the electrodes return to their first state of lead sulphate. The pasted cell is lighter than the other, and is more generally used in electric automobiles. This subject will be further treated upon under the head of Storage Batteries.

Acceleration. The increase of motion, or action. The time period of mutation in velocity.

Acetometer, or Acidometer. A graduated hydrometer used to ascertain the strength of acetic acid, or vinegar.

Active Coil, or Conductor. A coil, or conductor, conveying a current of electricity.

Adams Revolving Cylinder Motor. The Adams motor rated at 50 horse power has a five

cylinder engine with a bore and stroke of 5½ and 5 inches. In this motor the crankshaft is mounted vertically and has but one throw, the same as ordinarily used for a single-cylinder engine. This crankshaft is stationary—it never revolves, but the five cylinders revolve around it, as does the front wheel of a motor car on the steering spindle. The car is without a radiator, being an air-cooled machine; as the motor cylinders revolve, a cooling fan is not needed. It is without a muffler, each cylinder exhausting directly into a box which incloses the motor. The motor is directly above the transmission set, and as the motor is without a flywheel of any sort, it has been necessary for the designer to carry the double cone clutch within the selective gear set. The drive from the revolving cylinders to the gear-set is through a bevel gear attached to the base of the revolving crank case, and which meshes with a bevel gear on one of the transverse shafts of the transmission. From the transmission to the rear axle, a chain drive is employed. This car is without a float feed carbureter, but uses instead, a pump to maintain a gasoline level in a chamber in which a spraying nozzle and an air valve complete the carbureter. Instead of controlling the motor speed by advancing or retarding the spark, and opening and closing the throttle, it is done by controlling the length of time each intake valve is held open. This motor has but one cam to open all

of the ten valves. This cam being in two parts, it is possible to shift one, thereby varying the length of opening given a valve, and allowing a part of the mixture drawn into a cylinder to escape during a compression stroke, so that the explosive pressure can be varied from 90 lbs. to 0, and the power of the motor, and its speed

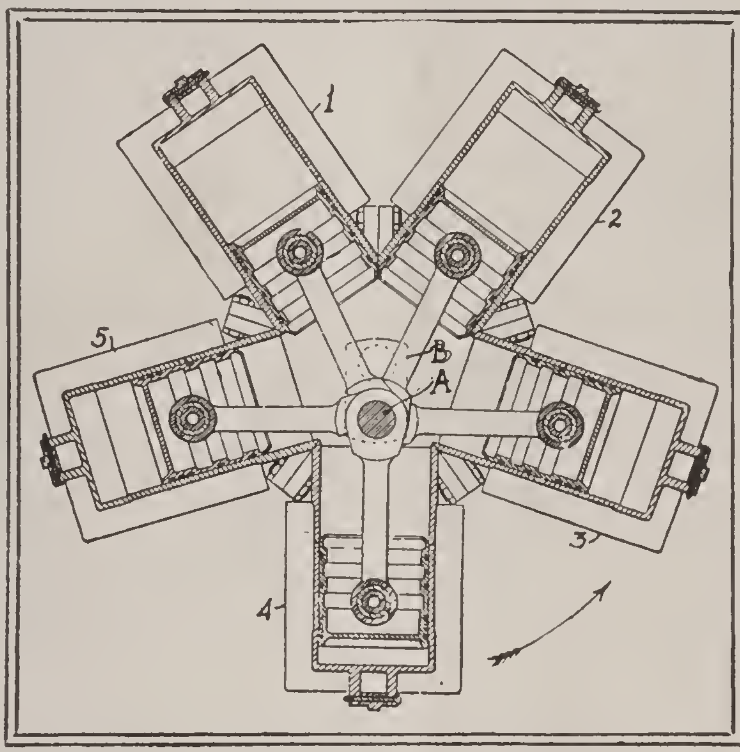


Fig. 1
Sectional View of Adams Motor

correspondingly varied. There is no branching manifold to convey the mixture to the cylinders, neither is there an exhaust manifold.

In Fig. 1 is a sectional view of the motor with its five cylinders designated respectively 1, 2, 3, 4 and 5, with five pistons shown in relative position. The crankshaft A has its one offset B. As each cylinder makes, in unison with the

other four, two complete revolutions, it passes through the four cycles of operation common to any four-cycle engine—inspiration, compression, explosion, exhaust. No. 4 cylinder is shown at the end of the out stroke, and the other four at different parts of the stroke; and as each in succession occupies the position of

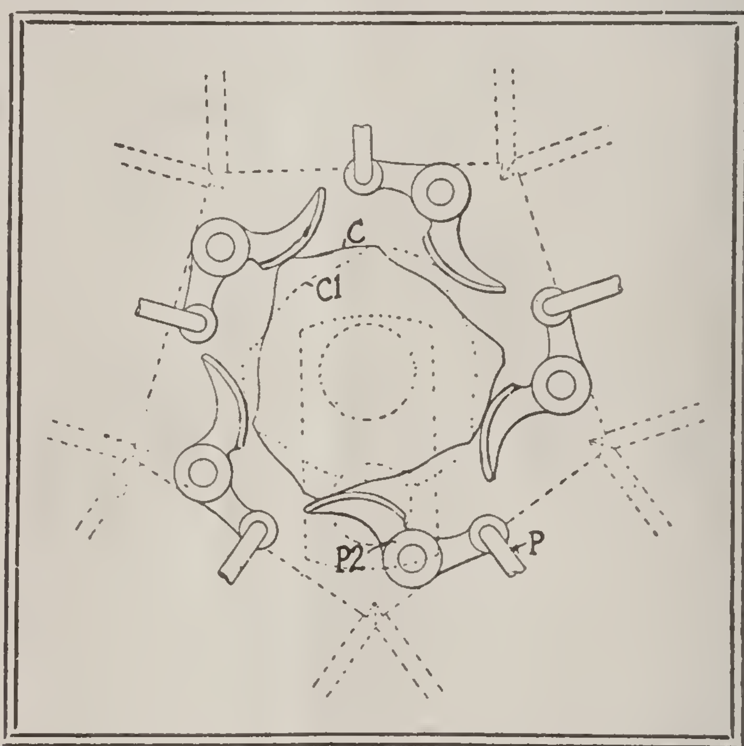


Fig. 2
Cam Diagram—Adams Revolving Cylinder Motor

No. 4, its piston will be at the end of the out stroke. When diametrically opposite to No. 4 they will be at the inner end of the stroke. Thus, as the five cylinders bolted firmly together to a hublike crankcase revolve, the pistons reciprocate in the cylinders, thus performing in perfect sequence. the four functions of cycling. The valves are located in the cylinder

heads and opened by rocker arms with push rods paralleling the cylinders on their lower sides. One diagram illustrates the single cam construction and valve operation. On the lower end of the crankshaft is the two-part cam C, CI—Fig. 2. The latter, shown in dotted line, is the movable half for controlling the intake valve period of opening. Both parts of the cam are stationary. On each of the five cylinders is a push rod P, the inner end of which has

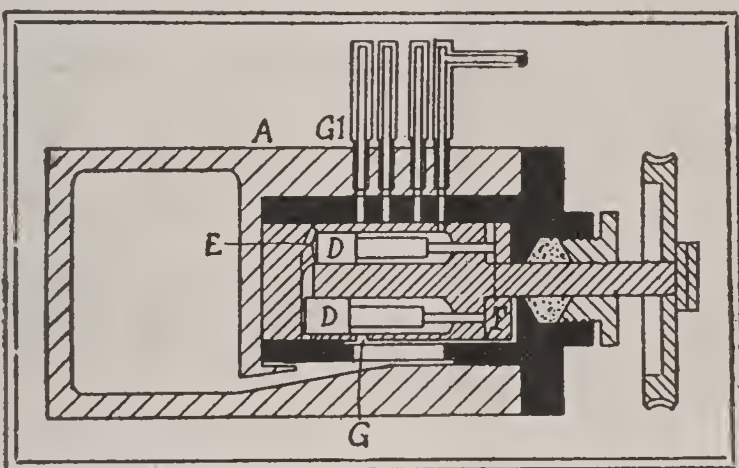


Fig. 3
Adams Four-Feed Oiler

a peculiar foot P2 pivoted on the crankcase with the curve portion bearing upon the cam, and the short straight arm connected with the push rod P. As the cylinder revolves, the rounded foot follows the contour of the cam, which has been designed so that the four cycles follow one another in order as they do in a four-cycle vertical engine.

The oiler employed on the motor is a four-feed plunger type, the four plungers being car-

ried in a rotating member, with the recipro-cation of the plunger produced by two end cams. The sectional illustration, Fig. 3, shows the casing A, the rotating member driven by gear. Two plungers D appear, and at their ends are the cams E and F, cam E to force each plunger in turn toward the right, and cam F to force it leftward. Revolving, the cylinder brings each plunger D in turn around so the opening G,

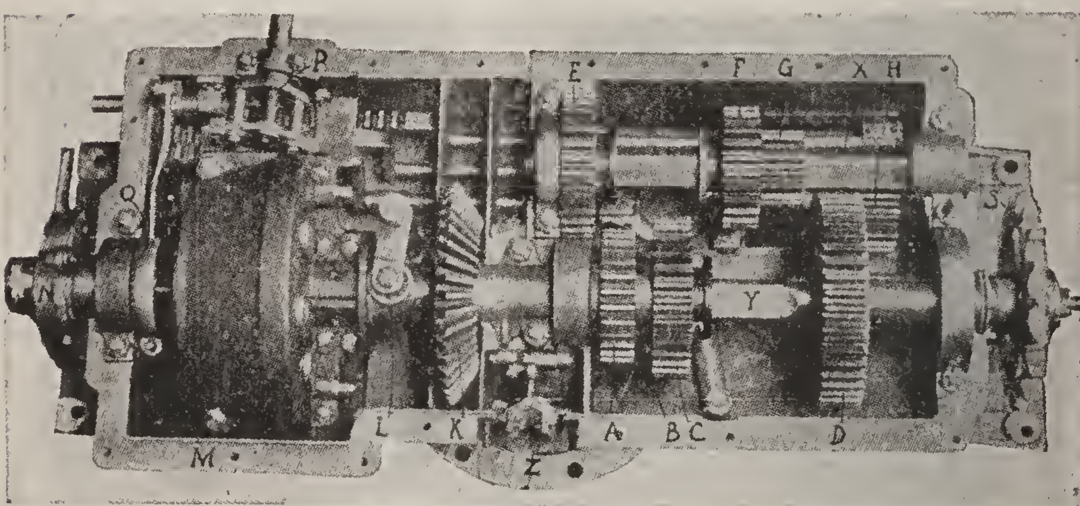


Fig. 4
Adams Three-Speed Selective Set Containing Cone Clutch

through which oil is drawn into the cylinder when the plunger is pushed out by the cam F, registers with a port. As the cylinder revolves the opening G soon will register wtih the out-let opening GI, at which time the cam E, forcing the plunger D rightward, sends two drops of oil through the lead GI to a bearing. Each of the four plungers has its openings G, and GI for taking in oil and delivering it to the oil leads.

The selective transmission shown in Fig. 4 has its shaft located transversely of the car, carrying the doublecone clutch M within it and driving by single chain from a sprocket S at one end. The bevel gear K constantly meshes with the bevel on the crankcase, and so receives the power from the motor. The reader should follow how the power passes from the bevel K to the sprocket S through the mechanisms of the gearset. The bevel K, and the external part of the clutch M are on a sleeve, whereas the gear A, and the internal part of the clutch are on the shaft carrying the sleeve. This shaft is in alignment with the shaft Y, and can be coupled with it by jaw clutch B. To get direct drive gear C is moved to gear A as illustrated, the jaw clutch B coupling the shaft Y with the shaft carrying the clutch M. This done, engaging the clutch M locks the gear K to the shaft Y on which is the sprocket S for chain drive. For intermediate speed, gears E and A are meshed, and also gears C and F, the power then passing to the countershaft X and then back to the squared shaft Y carrying the sprocket S. For slow speed gears A and E transfer to the countershaft, and gears D and G transfer to the shaft Y. In reversing G meshes with the idler H, which is of sufficiently wide face to also mesh with gear D when it is moved endwise. When not in use the idler H does not revolve. The clutch M is of the double-cone type. The central cone is of bronze

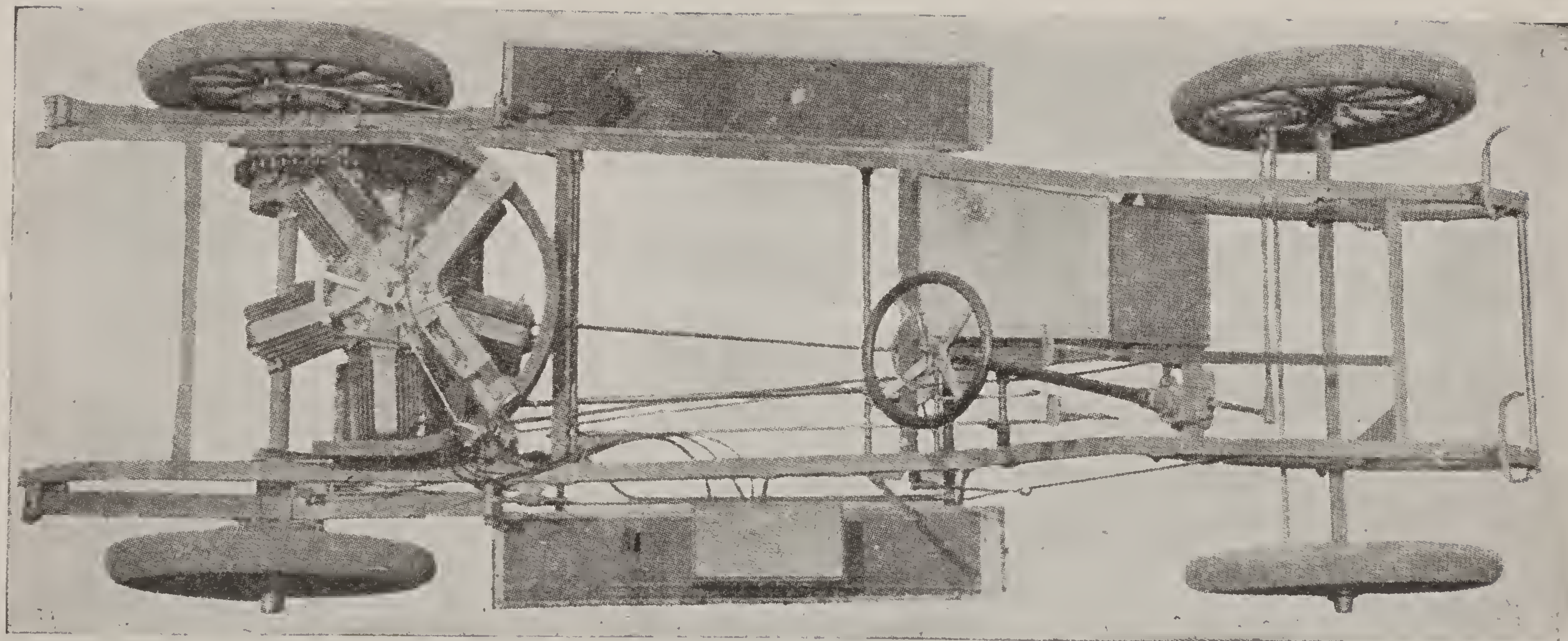


Fig. 5
Chassis of Adams-Farwell Car with Its Five-Cylinder Revolving Star Motor

with cork inserts, and the external and internal cones of cast iron. The eccentric O is for driving the gasoline pump supplying the carbureter. The housing N covers a ratchet wheel keyed to the shaft carrying the gear A and is connected to the driver's seat so the motor can be cranked through the gearset.

Fig. 5 is a plan view of the chassis, showing the mechanism of the car complete.

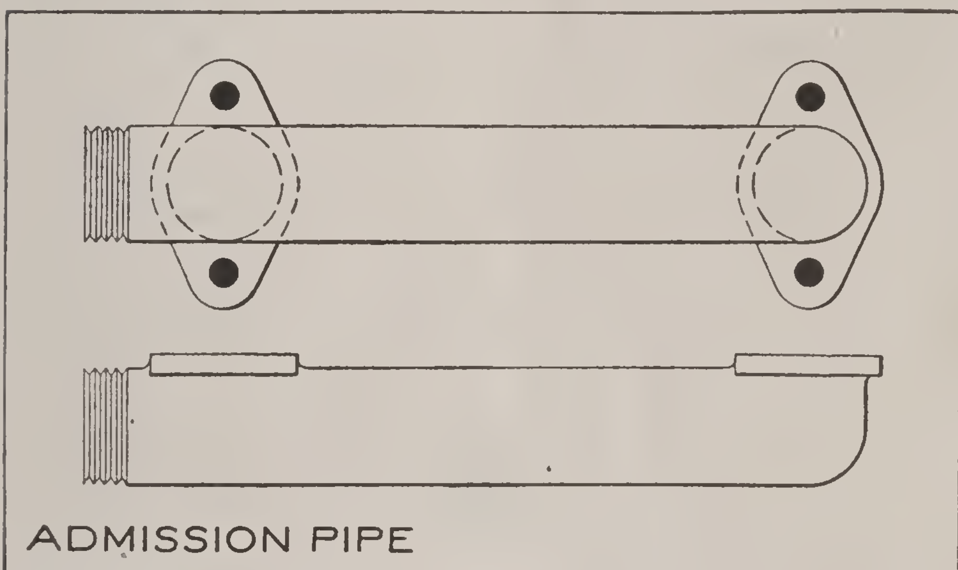
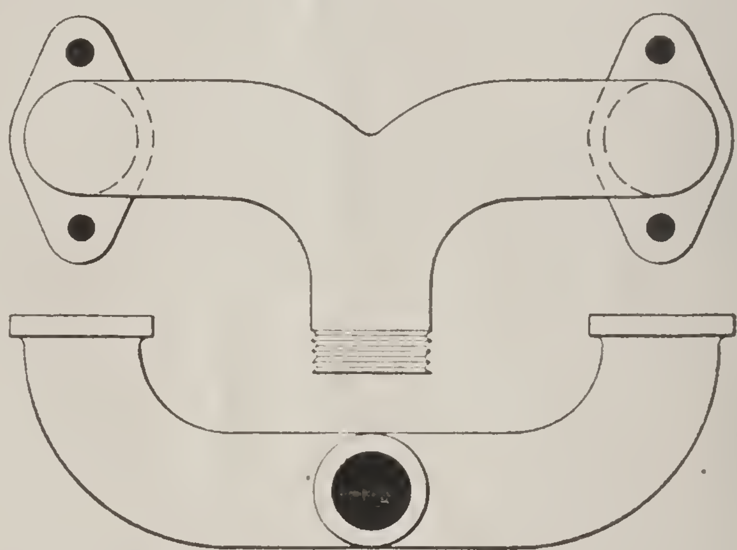


Fig. 6

Admission-pipes, Diameter of. The internal diameter of the admission or inlet-pipe leading from the carbureter to the admission-valve chamber should not exceed one-fourth the diameter of the motor cylinder.

This limitation is necessary in order to produce as great a partial vacuum as is possible in the admission-pipe. The carbureter should be placed as close as possible to the admission-valve chamber of the motor in order to secure

the best results. Short turns or bends in the admission-pipe greatly increase the air-friction in the pipe, and at high speeds greatly diminish the volume of the charge drawn into the cylinder by the inductive or suction action of the motor-piston. An admission-pipe with a side inlet and short bends, for a two-cylinder motor, is shown in Figure 6. Such forms of construc-



ADMISSION PIPE

Fig. 7

tion should be avoided whenever possible. Figure 7 shows an admission-pipe of approved design, with long bends, for a two-cylinder motor. The radius of curvature of the pipe on its center line should not be less than twice the outside diameter of the pipe. If space allows, a radius of three times the outside diameter of the pipe will give better results than two diameters.

Admission-valves, Diameter and Lift of. For a motor of any desired bore and stroke, and speed in revolutions per minute, the following formula may be used to determine the diameter of the valve opening:

Let B be the bore of the motor cylinder in inches, and S the stroke of the piston also in inches. As R is the number of revolutions per minute and D the required diameter of the valve opening, then

$$D = \frac{B \times S \times R}{15,000}$$

Example: Required the diameter of the admission-valve opening for a motor of 4½-inch bore and stroke at 1,000 revolutions per minute.

Answer: As 4½ multiplied by 4½ and by 1,000 equals 20,250, then 20,250 divided by 15,000 gives 1.35 inches as the diameter of the valve opening.

In practice, a motor of 4½ inches bore and stroke has, with a mechanically operated admission-valve, an opening of 1½ inches diameter and runs up to 1,200 revolutions per minute.

The upper view in Figure 8 shows clearly the diameter D referred to in the formula, as some persons are in the habit of referring to the outside diameter of the valve itself instead of the opening in the admission-valve seat. The center view in Figure 8 shows an admission-valve with a flat seat, which is known as a mushroom valve, on account of its shape. For this form

of valve to give a full opening the lift should be exactly one-fourth of the diameter of the valve opening: therefore if L be the required lift of the valve, and D the diameter of the valve opening, then

$$L = \frac{D}{4} = 0.25\,D$$

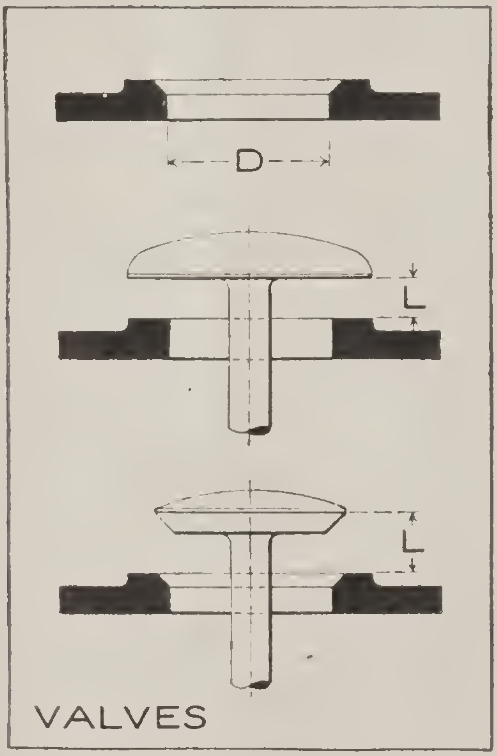


Fig. 8

The lower view in Figure 8 shows a valve with a bevel seat, having an angle of 45 degrees, which is most commonly used. The lift of this form of valve requires to be about three-eighths of the diameter of the valve opening; that is, if L is the required lift of the valve and D the diameter of the valve opening, then

$$L = \frac{D}{2.83} = 0.35\,D$$

The bevel-seat form of valve is to be preferred to the flat-seat or mushroom type of valve, for two reasons: first, that it is more readily kept in shape by regrinding, and second, it gives a freer and more direct passage for the gases, as will be plainly seen by reference to the lower view in Figure 8.

Table 1 gives the correct diameter of valve openings for motors from 3 by 3, to 6 by 6 inches bore and stroke, with speeds from 900 to 1,800 revolutions per minute, and piston velocities of 600, 750 and 900 feet per minute, for mechanically operated admission-valves.

TABLE 1.

DIAMETER OF MECHANICALLY OPERATED ADMISSION-VALVES.

Bore of Cylinder.	Stroke of Piston.	Piston Speed in Feet per Minute					
		600		750		900	
		Revs. per Minute.	Dia. of Valve Opening.	Revs. per Minute.	Dia. of Valve Opening.	Revs. per Minute.	Dia. of Valve Opening.
3	3	1200	0.72	1500	0.90	1800	1.08
3½	3½	1030	0.84	1285	1.05	1570	1.26
4	4	900	0.96	1125	1.20	1350	1.44
4½	4½	800	1.08	1000	1.35	1200	1.62
5	5	720	1.20	900	1.50	1080	1.80
5½	5½	655	1.32	820	1.65	965	1.95
6	6	600	1.44	750	1.80	900	2.16

Atmospheric or suction operated admission-valves require to be of somewhat larger diame-

ter than mechanically operated admission-valves, for two reasons: first, that the incoming charge has to lift the valve from its seat and keep it suspended during the suction stroke of the motor piston, and secondly on account of the resistance offered by the valve spring, which tends at all times to keep the valve on its seat. For an atmospherically operated admission-valve which will insure practically a full charge in the motor cylinder the formula should be

$$D = \frac{B \times S \times R}{12{,}750}$$

The proper diameter for atmospherically operated admission-valve openings may be readily found by increasing the required diameter given in the above table for mechanically operated admission-valves, by 15 per cent.

Example: What should be the correct diameter for the atmospherically operated admission-valve of a motor of 4½ inches bore and stroke, with a piston velocity of 750 feet per minute?

Answer: Under the column headed 750 and opposite 4½ by 4½, the diameter given is 1.35. Then 15 per cent of 1.35 equals 0.20, which, added to 1.35, gives 1.55 inches as the correct diameter for the valve opening under the conditions given.

Admission-valves, Forms of. Figures 9 and 10 are two forms of combined admission-valve

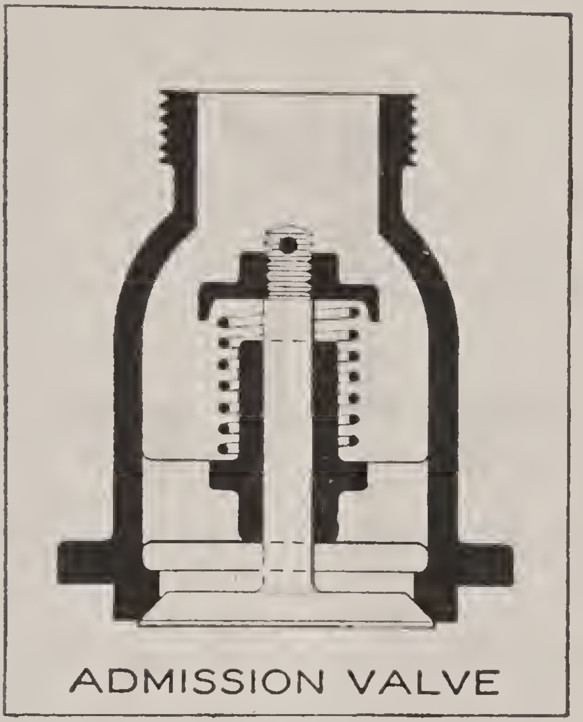


Fig. 9

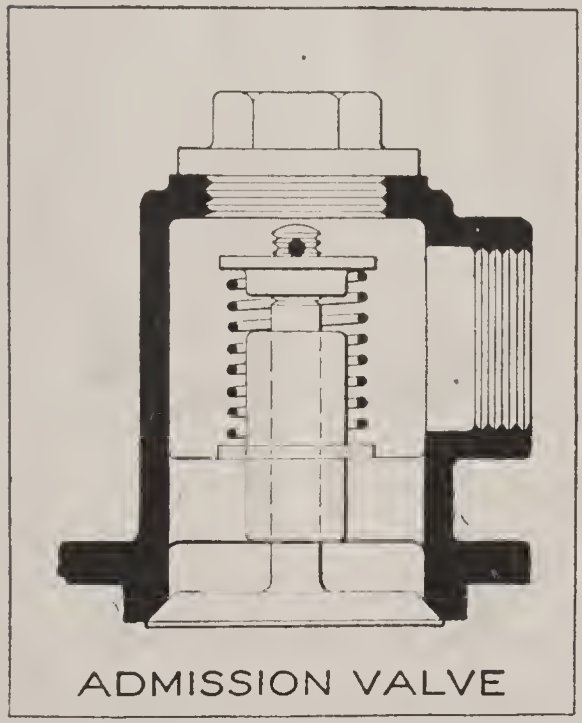


Fig. 10

and valve cage or chamber. Figure 9 has the inlet on top and Figure 10 on the side. Figures 11-12 show two forms of detachable or remov-

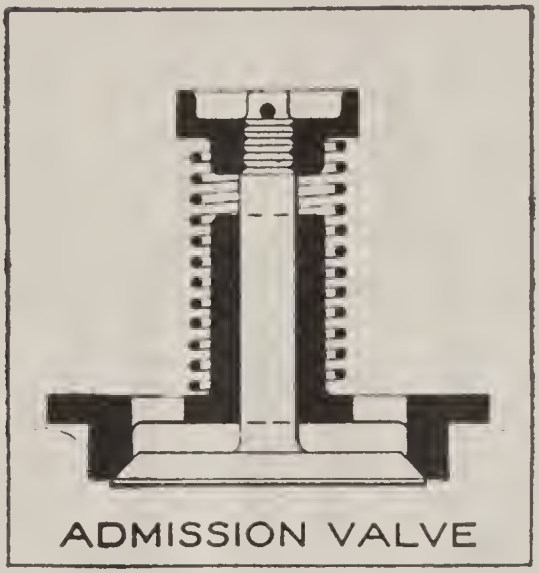


Fig. 11

able admission-valves. The one shown in Figure 12 may be removed from the motor without disconnecting the admission-pipe, as it screws

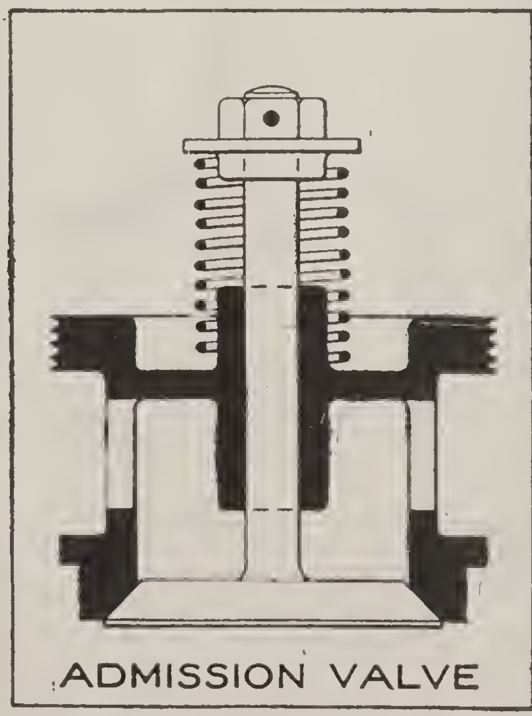


Fig. 12

into the combustion chamber, and has openings around the lower portion for the admission of the explosive charge to the valve.

Air. Air consists, by weight, of oxygen 77 parts and nitrogen 23 parts; by volume, of 21 parts oxygen and 79 parts nitrogen. One pound of air at atmospheric pressure, and 70 degrees, Fahr., occupies 13.34 cubic feet of space. One cubic foot of air weighs 1 1-7 ounces.

TABLE 2.

PROPERTIES OF COMPRESSED AIR

Comp. in Atmospheres.	*Mean Pressure.	Temp. in Degrees Fah.	*Gauge Pressure.	*Absolute Pressure.	*Isothermal Pressure.
1	0	60	0	14.7	
1.68	7.62	145	10	24.7	30.39
2.02	10.33	178	15	29.7	39.34
2.36	12.62	207	20	34.7	48.91
2.70	14.59	234	25	39.7	59.05
3.04	16.34	252	30	44.7	69.72
3.38	17.92	281	35	49.7	80.87
3.72	19.32	302	40	54.7	92.49
4.06	20.57	324	45	59.7	104.53
4.40	21.69	339	50	64.7	116.99
4.74	22.76	357	55	69.7	129.84
5.08	23.78	375	60	74.7	143.05
5.42	24.75	389	65	79.7	156.64
5.76	25.67	405	70	84.7	170.58
6.10	26.55	420	75	89.7	184.83

*In pounds per square inch.

Air Properties of Compressed. Table 2 gives the Mean pressure, Temperature in degrees Fahr., Gauge pressure, Absolute pressure and the Isothermal or heat pressure of air under compression of from 1 to 6.10 atmospheres.

As energy in the form of power must be used to compress air to any desired pressure, so is energy in the form of latent or stored heat given up by the air during the operation of compression. This heat consequently increases the pressure resulting from the compression,

but not directly in proportion to the degree of compression in atmospheres.

This increase of pressure above the Adiabatic or calculated pressure is known as the Isothermal or heat-pressure. As the values of this pressure cannot be calculated by the use of ordinary mathematics, but involve the use of logarithms, Table 2 gives these values for each degree of compression given.

Many persons who are not familiar with the properties of gases, estimate the pressure resulting from the compression to a given number of atmospheres, as the number of atmospheres multiplied by the atmospheric pressure, which at sea level is taken as 14.7 pounds per square inch.

This assumption is erroneous and will often lead to grievous mistakes in motor design, generally giving too much compression, which results in premature ignition, commonly known as backfiring. Such methods of calculation would be true if the air, after compression, was stored in a reservoir and allowed to cool, but under no other conditions.

Air-Cooled Automobile Engines. The successful air cooling of an engine cylinder depends chiefly on an abundant flow of cool air over it. Some cylinders, however, are arranged to utilize a more rapid flow than others. Generally speaking, the designer can take his choice between a comparatively plain cylinder surface over which a current of air can flow almost un-

checked, and a cylinder with its heat-radiating surface greatly multiplied by numerous pins, deep ribs, or other projections. These projections increase greatly the radiating surface, but tend to obstruct the flow of air, although they aid in carrying away the heat. In the latter

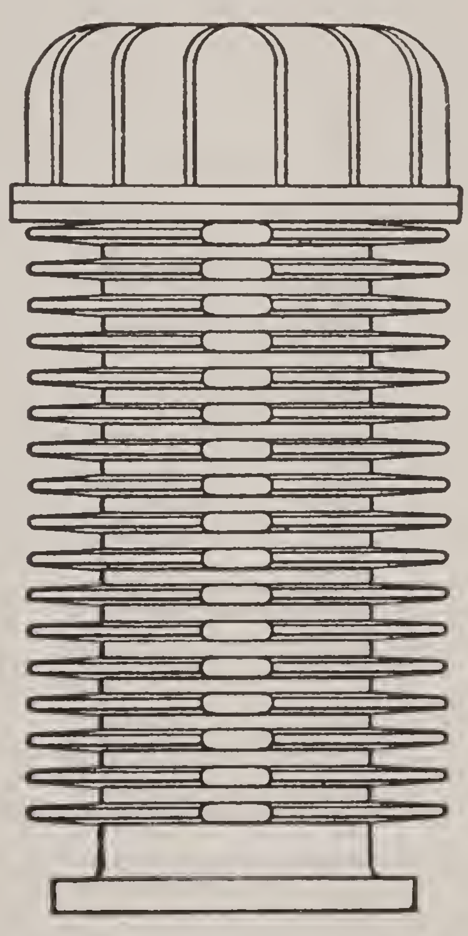


Fig. 13

case, the velocity of the air stream does not need to be high, provided it is continuous; while in the former case, a constant and abundant supply of air is essential.

Air Cooling Systems. In modern automobile practice two systems of cooling are used—the air system and the water system, each of which

has its adherents. As its name indicates, the air cooling system allows the air to strike the exterior of the engine cylinder, and thus carry off the excess of heat generated within it. To give the radiating surface, required for air cooling, the exteriors of the cylinders are either

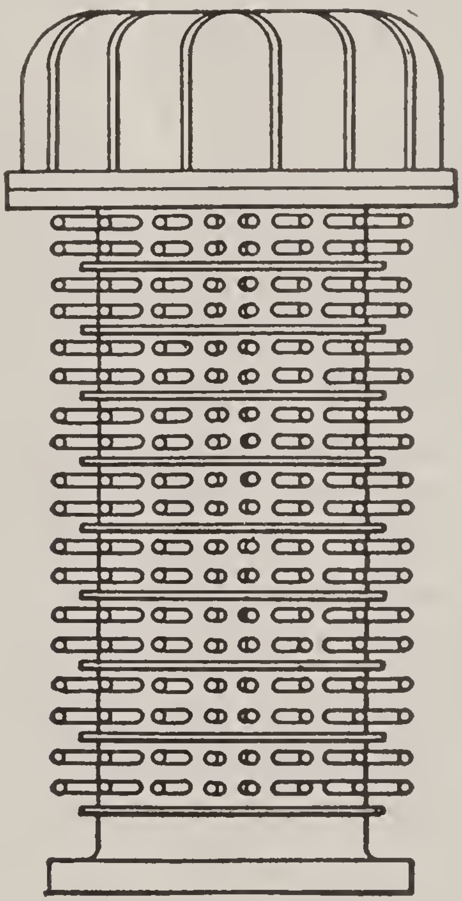


Fig. 14

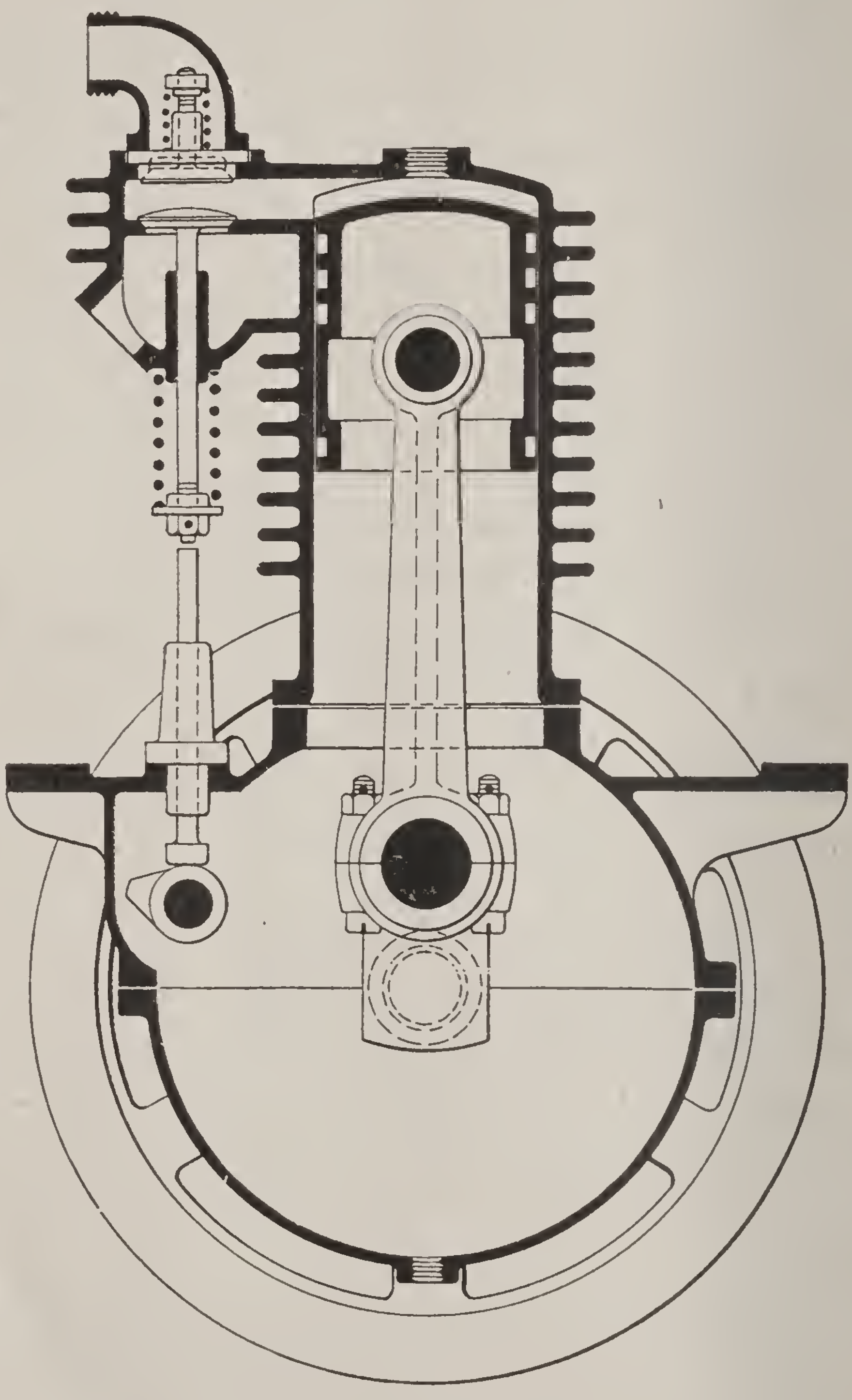
grooved or corrugated, as shown in Fig. 13, or the surface of the cylinder is studded with metal pins or fins, as shown in Fig. 14, so as to present as much surface to the outside air as possible. The object in the construction of all air-cooled motors is to make their external surfaces offer as great a surface to the air as pos-

sible, and to furnish these surfaces with as large a supply as possible. A fan is therefore used, driven by the engine itself, which constantly directs a current of fresh, unheated air upon the surface of the cylinder.

Fig. 15 is a sectional view of a vertical air-cooled gasoline motor. The radiating ribs cast around the cylinder and valve chamber are plainly discernable. This motor has a detachable atmospherically operated admission-valve, without packing. The valve and cage may be removed by simply removing two nuts.

Air, Relation of to Gasoline. Owing to the fact that automobile gasoline is composed of various percentages of the several available fractions of hydrocarbon distillates, it is not possible to fix an exact basis for the relative proportions of air to fuel. However, the average carbureter is capable of altering the ratio of air to fuel over broad ranges, and it is not necessary to know the exact ratio in order to attain the best results. But it is necessary to approximate an average ratio as nearly as possible in designing and adjusting carbureters in order to allow for these variations up and down.

The mixture becomes explosive when 10,000 volumes of air dilute one volume of gasoline, but the best results follow when the ratio is one volume of liquid gasoline to 8,000 volumes of air. With one of gasoline to 3,500 of air the mixture is non-explosive.



AIR-COOLED MOTOR

Fig. 15

Air, Relation of in Gasoline Mixture. Gasoline is a somewhat uncertain mechanical mixture of several hydrocarbon (fractional) distillates, in which the compound "hexane" is supposed to be the major portion. This compound answers to the formula $C_6 H_{14}$, the products of combustion of which will be $CO_2 + CO + H_2O$, in which CO will not be found if the combustion is complete. A final expression of complete combustion will be as follows:

$$2 C_6 H_{14} \times 19 O_2 = 12 CO_2 + 14 H_2 O.$$

Taking into account the atomic weight of the elements, the volume of air required in the complete combustion of 1 pound of hexane may be set down as follows—atomic weight of the elements involved:

Carbon (C)	12
Hydrogen (H)	1
Oxygen (O)	16

The molecular weight of $C_6 H_{14} = 6 \times 12 + 14 \times 1 = 86$; the required oxygen will weigh (molecular) $19 \times 16 = 304$; the ratio of the compound hexane, then, to the combining oxygen will be

$$\text{Ratio} = \frac{304}{86} = 3.54, \text{ nearly.}$$

Considering 1 pound of hexane, the weight of oxygen required for its complete combustion will be equal to the ratio as above given, i.e., 3.54 pounds, nearly.

Since the oxygen is taken from the air, it is

necessary to consider dry air in the attempt to determine as to the weight of the same. This air, under a pressure of 1 atmosphere, and at a temperature of 60 degrees Fahrenheit contains 0.23 pounds of oxygen, hence the required air=

$$\frac{3.54}{.23} = 15.39, \text{ in pounds.}$$

Air Resistance, Horsepower Required to Overcome. The power required to move a plane surface, such as the vertical projection of an automobile, against the air, does not become of much importance until the car attains a speed of 10 to 12 miles per hour, when it becomes an important factor.

The horsepower required to propel an automobile against the resistance of the air may be approximately calculated by the following formula. Let V be the velocity of the car in feet per second, and A the projected area of the front of the car in square feet—this may be assumed as the height from the frame to the top of the body multiplied by the width of the seat at the floor line of the car—let H.P. be the horsepower required to overcome the air resistance, then

$$\text{H.P.} = \frac{V^3 \times A}{240{,}000}$$

To simplify the use of the above formula, Table 3 gives speeds in miles per hour corre-

sponding to their respective velocities in feet per second and also cubes of velocities in feet per second.

TABLE 3.

CUBES OF VELOCITIES IN FEET PER SECOND.

Miles per Hour of Car.	Feet per Second.	Cube of Velocity in Ft. per Second.	Miles per Hour of Car.	Feet per Second,	Cube of Velocity in Ft. per Second.
10.2	15	3,375	34.0	50	125,000
13.6	20	8,000	40.9	60	216,000
17.2	25	15,625	47.7	70	343,000
20.4	30	27,000	54.4	80	512,000
27.2	40	64,000	61.3	90	729,000

To ascertain approximately the horsepower that will be necessary to drive a car against a wind of known velocity, the speed of the car must be added to that of the wind, and the required horsepower may be found either by use of the formula given or by reference to Table 4, which gives the horsepower per square foot of projected surface required to propel a car against the resistance of the air, with varying speeds in miles per hour or velocities in feet per minute.

TABLE 4.

HORSEPOWER REQUIRED PER SQUARE FOOT OF SURFACE, TO MOVE A CAR AGAINST AIR RESISTANCE.

Miles per Hour of Car.	Feet per Second.	Horse-power per Square Foot of Surface.	Miles per Hour of Car.	Feet per Second.	Horse-power per Square Foot of Surface.
10	14.7	0.013	40	58.7	0.84
15	22.0	0.44	50	73.3	1.64
20	24.6	0.105	60	87.9	2.83
25	36.7	0.205	80	117.3	6.72
30	44.0	0.354	100	146.6	13.12

The horsepower given by the formula and Table 4 simply refers to the additional power

necessary to overcome air resistance and not to the actual power required to propel a car at a given speed; this is entirely another matter.

Alcohol. There are two kinds of alcohol; methyl, or wood, alcohol, CH_4O, and ethyl, or grain, alcohol, C_2H_6O. The former has been found objectionable for use in internal-combustion engines, because it apparently liberates acetic acid, which corrodes the cylinders and valves.

As alcohol is a fixed product, and the same the world over, it has a great advantage as a motive power over gasoline and other petroleum products. Denatured alcohol contains 4,172 heat units per pound as compared to 18,000 for gasoline, and, as its cost is higher, this fuel would not seem practicable from an economic standpoint. By mixing the alcohol, however, with a high grade of gasoline, its price is lowered, and the number of heat units per pound greatly increased. Mixtures containing 50 per cent alcohol have a calorific power of 11,086 heat units per pound, and as it has been found by numerous tests in France that it requires no more of this mixture than of gasoline to develop a certain power, its efficiency is considerably greater, reaching a value of 24 per cent as compared to 16 for the gasoline motor. In some recent experiments in France with a motor specially constructed for the use of alcohol, the consumption was lowered to 0.124 pound

per horse power, using 50 per cent carburetted alcohol.

Grain, or ethyl, alcohol has a specific gravity of .795, and may be obtained by distillation from corn, wheat, and other grains, potatoes, molasses, or anything containing sugar or starch. When pure, it absorbs water rapidly from the air, more rapidly in fact than it loses its own substance by evaporation; but when diluted to the proportion of about 85 per cent. alcohol and 15 per cent. water, it evaporates practically as if it were a single liquid and not a mixture. In France, it is denatured for motor purposes by the addition of 10 liters of 90° wood alcohol, and 500 grams of heavy benzine, to 100 liters of 90° ethyl alcohol. In Germany, benzol is added to the extent of 15 per cent. for denaturing, no wood alcohol being used. In the United States the so-called "denatured" alcohol, which is that used in the arts and industries, is composed of ethyl or grain alcohol, to which have been added certain diluents calculated to make it unfit for drinking. The Internal Revenue regulations specify that to 100 volumes of ethyl alcohol there must be added 10 volumes of methyl (wood) alcohol and one-half of one volume of benzine, or to the same quantity of ethyl alcohol must be added 2 volumes of wood alcohol and one-half of one volume of pyridine bases.

As compared with gasoline as a fuel for in-

ternal-combustion motors, alcohol exhibits several striking peculiarities.

First, the combustion is much more likely to be complete. A mixture of 90° alcohol vapor and air will burn completely when the proportion varies from 1 of the vapor with 10 of air to 1 of the vapor with 25 of air, thus exhibiting a much wider range of proportions for combustibility than is the case with gasoline. As the combustion is complete, the exhaust is practically odorless, consisting only of water vapor and carbon dioxide.

Second, the inflammability of an alcohol mixture is much lower. This is due partly, no doubt, to the presence of water in the alcohol, which is vaporized with the alcohol in the engine and must be converted into steam at the expense of the combustion.

For these reasons, the compression of an alcohol mixture is carried far above that permissible with a gasoline mixture, without danger of spontaneous ignition. The rapidity of combustion of alcohol in an engine is considerably less than that of a gasoline mixture, and for this reason the speed of alcohol engines must be somewhat slow.

The facts that alcohol of sufficient purity for use in engines can be produced from the waste products of many of the country's industries, and at a nominal cost, and that many thousands of acres of land, unfit for the cultivation of first-class grain, etc., may be utilized for the

production of vegetable matter rich in the elements which form alcohol upon fermentation, lead to the supposition that within a few years, or as soon as there is a sufficient demand for alcohol to warrant the erection of special distilleries, it may be purchased at such a low price that it will not only be commercially possible, but will in a measure force gasoline and other petroleum distillates from the field.

A carbureter designed to operate with alcohol can always be used with gasoline, but the reverse conditions are not true, that is, a gasoline carbureter will not operate successfully with alcohol, except in some rare instances. Alcohol evaporates slower than gasoline and its time of combustion is much slower, but it maintains its mean effective explosion pressure far better than gasoline.

Explosive motors fitted with alcohol carbureters make far less noise than when using gasoline as a fuel, due to the slower burning of the explosive charge, they also make less smoke and smell.

The jet or spray of a float-feed carbureter will have to pass nearly 40 per cent. more liquid fuel than when using gasoline, consequently the opening in the nozzle must be proportionally larger.

A carbureter using alcohol must be fitted with some form of device to heat the alcohol to ensure rapid evaporation—this is usually done by

surrounding the mixing-chamber with an exhaust-heated jacket.

The same quantity of alcohol will only take a car two-thirds of the distance that gasoline will, hence greater storage capacity would be needed on a car using alcohol as a fuel.

An explosive motor designed to use alcohol requires a greater degree of compression than a motor of the same bore and stroke designed to use gasoline, in order to develop the same power.

Alternating Current, Use of. It is not only useless but absolutely injurious to attempt to charge a storage battery directly from an alternating current circuit. This can only be done by means of a rotary converter, which is in reality a motor-generator, receiving its power from the alternating current and transforming it into a direct current which can be used to charge the batteries.

Aluminum. A soft ductile malleable metal, of a white color, approaching silver, but with a bluish cast. Very non-corrosive. Tenacity about one-third that of wrought iron. Specific gravity 2.6. Atomic weight 27.1. It is the lightest of all the useful metals, with the exception of magnesium.

Aluminoid, Composition and Use of. Aluminoid is composed by weight of 60 parts aluminum, 30 parts tin and 10 parts zinc. It has a tensile strength of about 18,000 pounds and is a very suitable material for crank chambers, gear

cases and small brackets, being light, extremely ductile and readily machined.

Aluminum Solder. The following formula is for a solder which will work equally well with aluminum or aluminoid: Tin, 10 parts—cadmium, 10 parts—zinc, 10 parts—lead, 1 part. The pieces to be soldered must be thoroughly cleansed and then put in a bath of a strong solution of hyposulphate of soda for about two hours before soldering.

Alloys, Composition of. The proper composition of alloys of metals for the bearings and other parts of an automobile is a very important consideration from a constructive standpoint. Table 5 gives the composition of various alloys of metals and also solders for different uses.

TABLE 5.
COMPOSITION OF ALLOYS.

	Tin.	Copper.	Zinc.	Antimony.	Lead.	Bismuth.
Bronze, for Motor bearings.......	13	110	1	...	...	...
Bronze, for Axle bearings........	25	160	5	...	...	...
Brass, for light work, other than bearings	...	2	1	...	...	...
Bronze flanges, to stand brazing...	...	32	1	...	1	...
Genuine Babbitt metal...........	10	1	...	1	...	...
Bronze, for bushings	16	130	1	...	...	...
Metal to expand in cooling, for patterns	...	...	...	2	9	1
Genuine bronze	2	90	5	...	2	...
Solder, for tin	1	...	...	...	2	...
Spelter, hard	...	1	1	...	...	...
Spelter, soft	1	4	3	...	...	...

American Locomotive Carbureter. The float feed carbureter used on this car is automatic in regulating the admission of mixture to the cyl-

inders. The air is heated on its way to the carbureter, and a bypass operated by hand from the dash adjusts the mixture to varying atmospheric conditions.

Ammeter, Construction of. Ammeters for automobile use are constructed on the principle

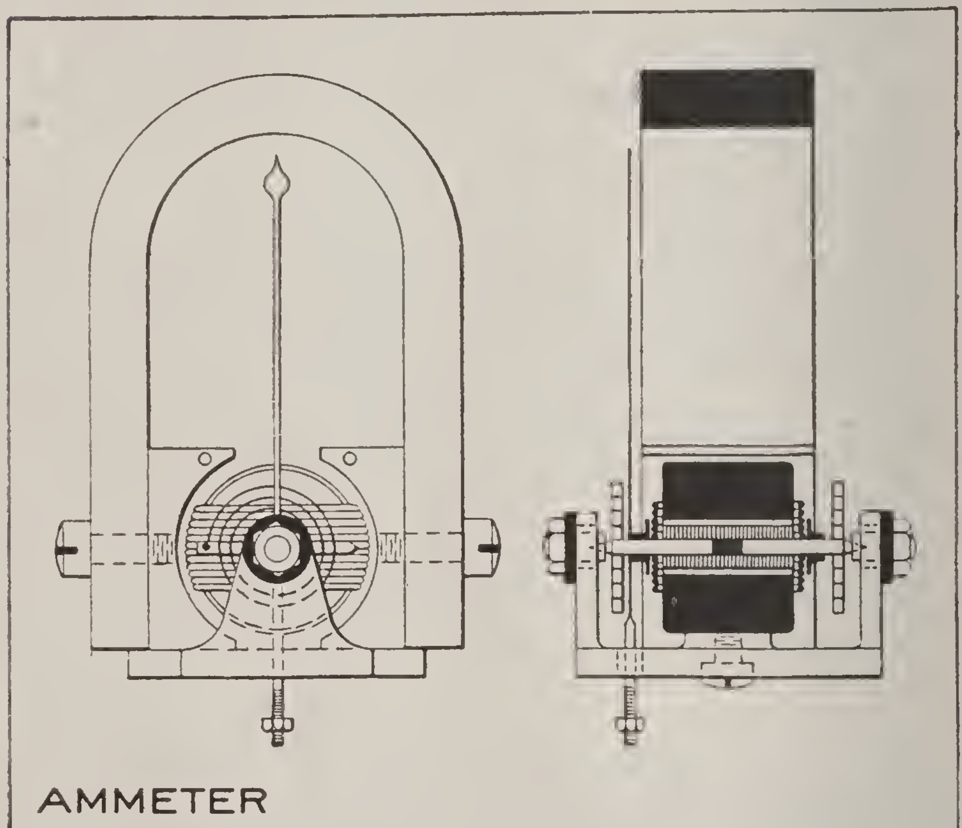


Fig. 16

of the D'Arsonval galvanometer with a permanent magnetic field. The special feature is a small oscillating coil mounted on cone-point bearings surrounding a stationary armature which is centrally located between the pole-pieces of a permanent magnet, with a pointer or index-finger which indicates the electrical variations on a graduated scale.

The construction of an ammeter is fully show in the two views in Figure 16. The permanent magnets used in its construction are of a special quality of hardened steel, made only for this purpose and possessed of great magnetic permeability. The pole-pieces, which are of soft steel and well annealed, are attached to the inside of the lower part of the magnet legs, the joints between the pole pieces and the mag-

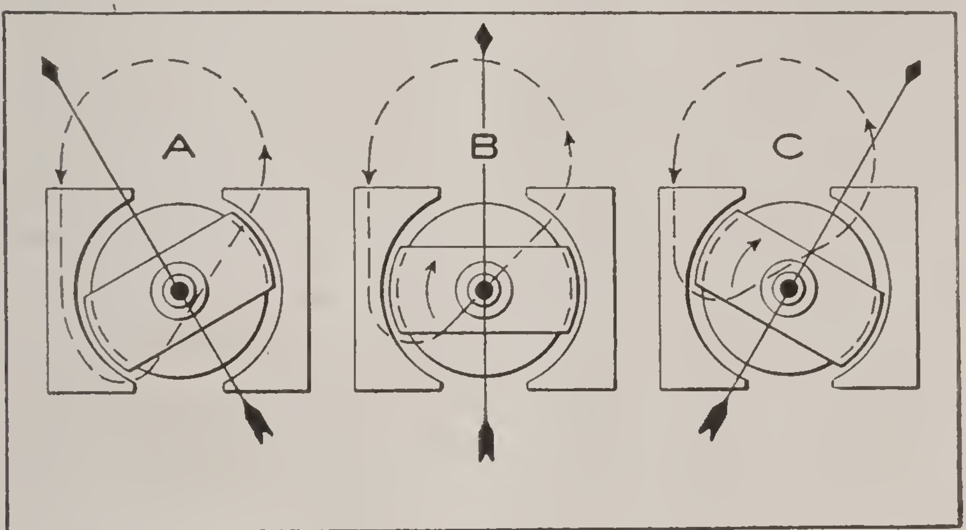


Fig. 17

net legs are usually ground to insure the full efficiency of the magnetic circuit. The soft iron core of the coil is for the purpose of rendering uniform the magnetic field in which the coil must oscillate. A coil of insulated wire is wound upon the stationary armature at right angles to its axis, in the same manner that thread is wound upon a spool, and is short-circuited on itself, that is to say, the ends of the wire forming the coil are connected together. This coil of wire is for the purpose of choking

the magnetism induced in the stationary armature by the oscillating coil, as it generates what are known as eddy currents within itself, thus making the instrument periodic, or dead-beat, in its indications. Around the armature core and outside the short-circuited coil of wire is wound the active or oscillating coil and at right angles to the direction of the winding of the first coil. The oscillating coil consists of a number of turns of fine insulated copper wire, to which the current is conveyed through the medium of the controlling springs at each end of the spindle, which is in two parts and connected together by a suitable sleeve of insulating material, as shown.

The pointer or index-finger is made with a boss or hub to go over the end of the spindle of the active coil and also has an extension with a small counterweight or balance, so that the pointer may be accurately adjusted.

The only difference in the construction of a voltmeter and an ammeter is that in the former the active or oscillating coil is in series with a high resistance, while in the latter it is connected across the terminals of a shunt-block. The voltmeter is in reality an ammeter, the resistance serving to keep the amperage in step with the voltage.

Reference to the three views, marked respectively A. B and C in Figure 17, will show clearly the principle of the operation of an ammeter or voltmeter, and the reason that they

record the current strength or pressure of an electric current accurately.

Ammeters are of two kinds, the double-beat type, as shown in Figure 16, which indicates the current strength or number of amperes flowing in the electric circuit, without any regard to the polarity of the terminals of the circuit, by the pointer or index-finger moving either to the right or to the left of the zero position. The

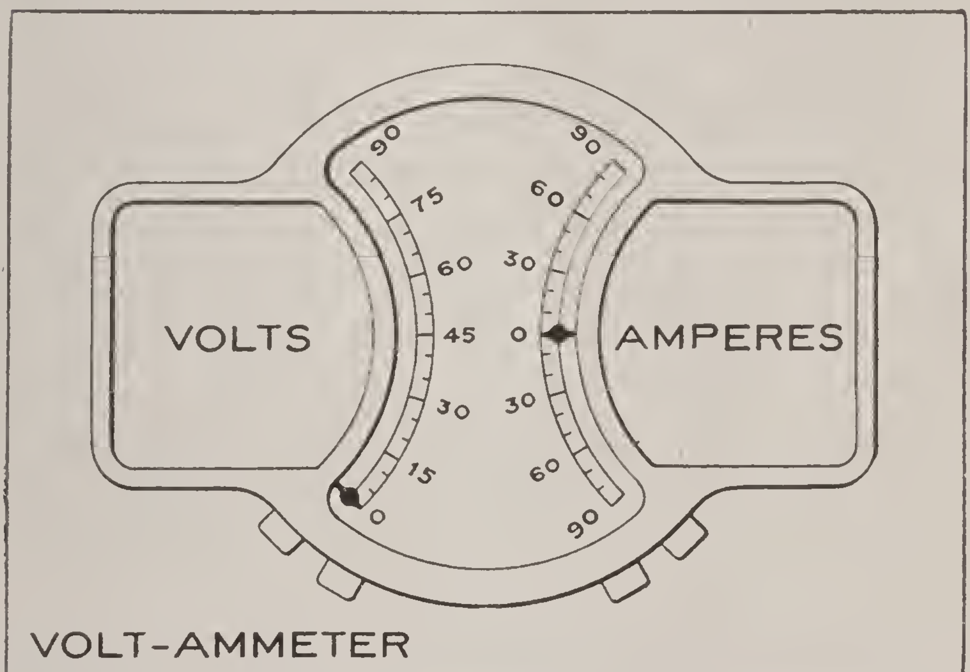


Fig. 18

single-beat type of ammeter only records in one direction, by the pointer moving from the left to the right of the graduated scale of the instrument, consequently the polarity of the terminals of this type of ammeter are marked on its outer casing and the polarity of the terminals of the electric circuit must consequently be determined before connecting them with the ammeter.

A volt-ammeter, such as is commonly used on electric automobiles, is shown in Figure 18. This instrument is simply a voltmeter and a double-beat ammeter mounted on a single base and enclosed in a common case, with their graduated scales adjoining each other.

Ampere. The unit of electric current flow. An ampere is that volume of current which would pass through a circuit that offered a resistance of one ohm, under an electromotive force of one volt.

Ampere-hour, Definition of. The term ampere-hour is used to denote the capacity of a storage or a closed-circuit primary battery for current. A storage battery that will keep a 2 ampere lamp burning for 8 hours is said to have a 16 ampere-hour capacity. In a similar manner an 80 ampere-hour battery would operate the same lamp 40 hours. The voltage of a battery does not enter into the calculation of its ampere-hour capacity.

Anchoring Top Irons. Cape cart hood irons are sometimes attached to the front seat as illustrated in Fig. 22, which indicates the appearance inside the arm of the front seat with the upholstery stripped away. The lower end of the iron goes through the overhanging part of the seat and the nut, A, is on the outside. The iron is steadied by an ordinary wood screw, B, which goes into the framing of the arm. If the iron is curved as the sketch shows, there is a considerable leverage on B, tending to break

it off. If it breaks the free movement of the arm tears the upholstery. A permanent job can be made by drilling the hole through which B passes and putting in a slightly larger screw, C, and also putting on a strap, D, beneath it. This strap, D, then does the greater part of the work, and has the effect of causing any twist applied to the iron to be held by the screw, C,

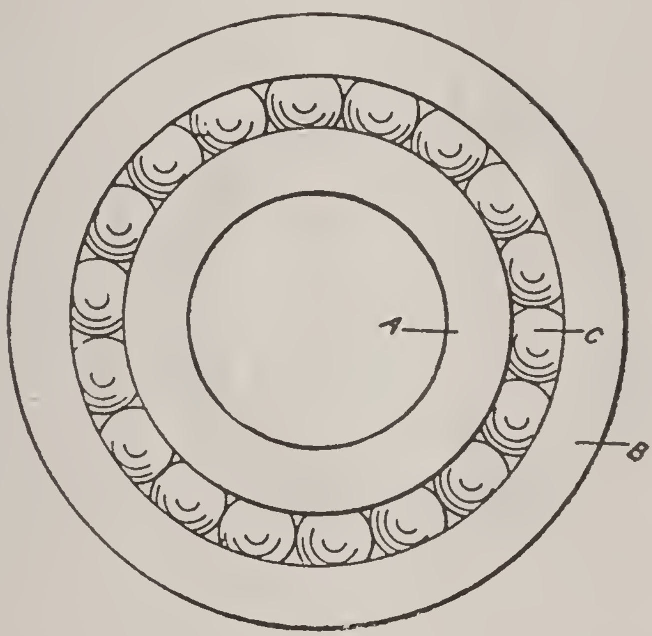


Fig. 19
Annular Ball Bearing

where it enters the wood, insead of exerting a leverage against it just under the head.

Angle Iron. A bar of iron rolled into the shape of the letter L, or V.

Annular Ball Bearings. In the annular ball bearing, Fig. 19, a race of balls C is contained between an inner retainer A and an outer race B, there being grooves in the opposing surfaces of these to receive the balls. In a Hess-Bright

bearing of this type, as illustrated in Fig. 20, the entire space between the races C and B is not occupied by balls, but is utilized in different ways. In this only enough balls to make a half circle in the bearing are used, and these are spaced apart by means of small helical springs. These springs contain oil pads of felt, and are headed by sheet-metal discs that extend far

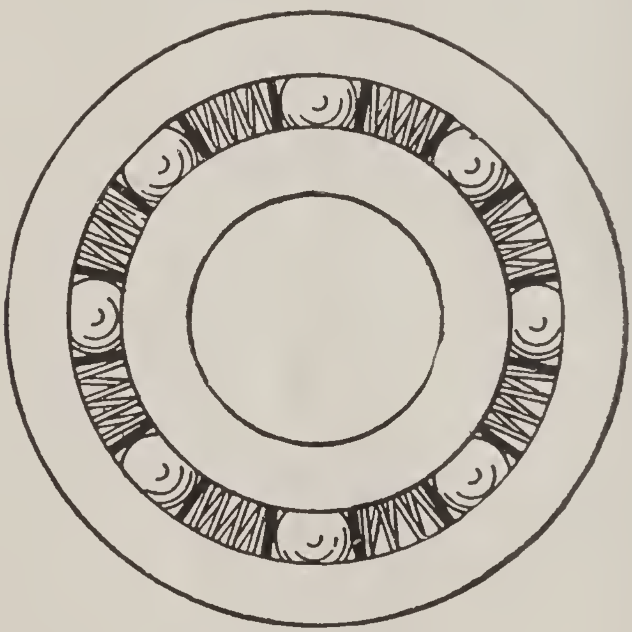


Fig. 20
Hess-Bright Bearing

enough into the grooves to prevent sidewise displacement of the springs, without, however, producing any more than a negligible friction. Assembling this bearing one race is placed eccentric to another race and the requisite number of balls slipped into positions, after which the races are made concentric and the balls regularly distributed. This done, the separating springs with lubricating means are installed.

Once the springs are in place the tension of them is such as to make the bearing self-contained.

Annoying Squeaks, Remedy for. A squeak that is caused by the edge of a door rubbing against its pillars may be remedied as shown

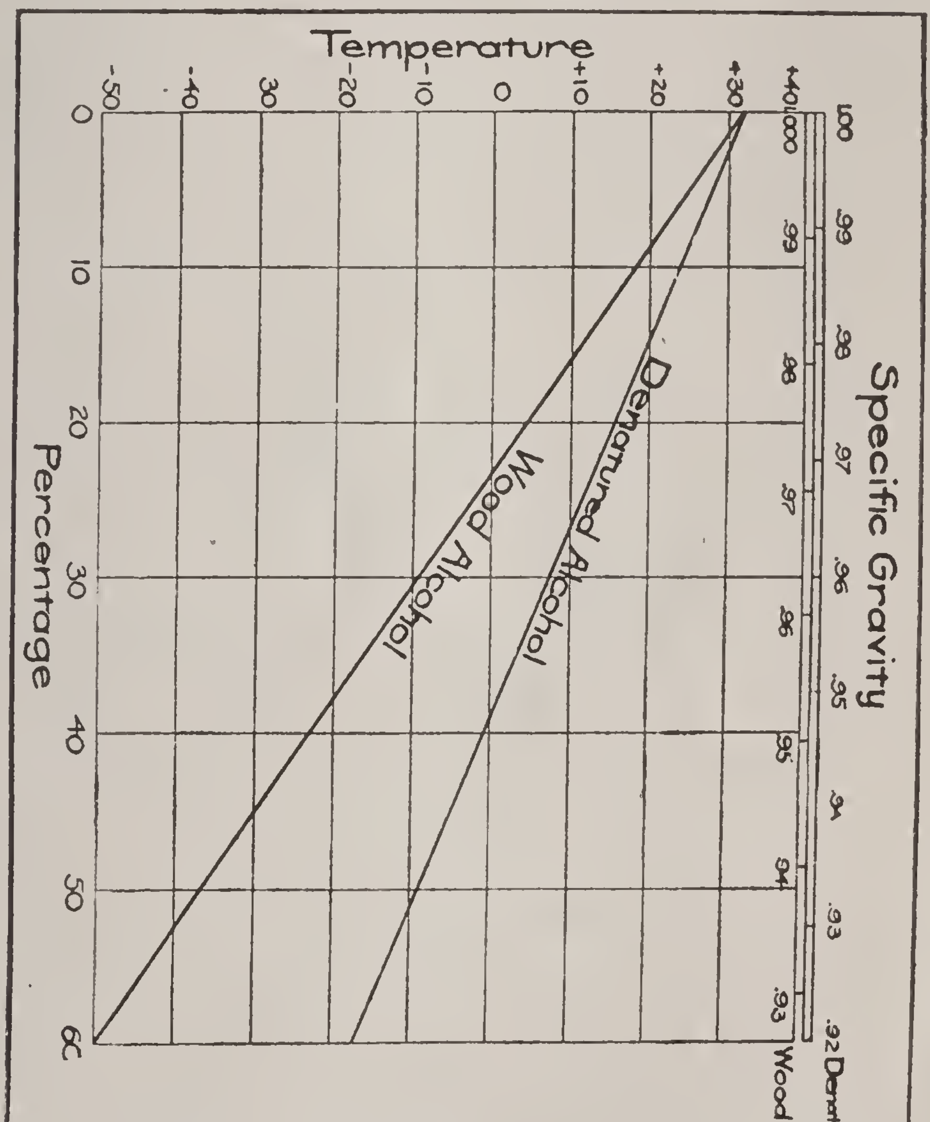


Fig. 21

in Fig. 23. This rubbing, generally occurring at A, Fig. 23, is brought about by a sagging of the body in the center, and may be remedied by placing a leather washer of the required thickness around the body bolt, between the body

and the frame at B. This sagging may be due to a sagging of the frame, in which case the motor and change-gear case may also require a little lining up. Body squeaks of the same nature occasionally occur at C, or at D when the body is jointed to the dash at D, and for the same reasons as above stated. Another cause is due to negligence on the part of repair men to replace one or two of the washers originally

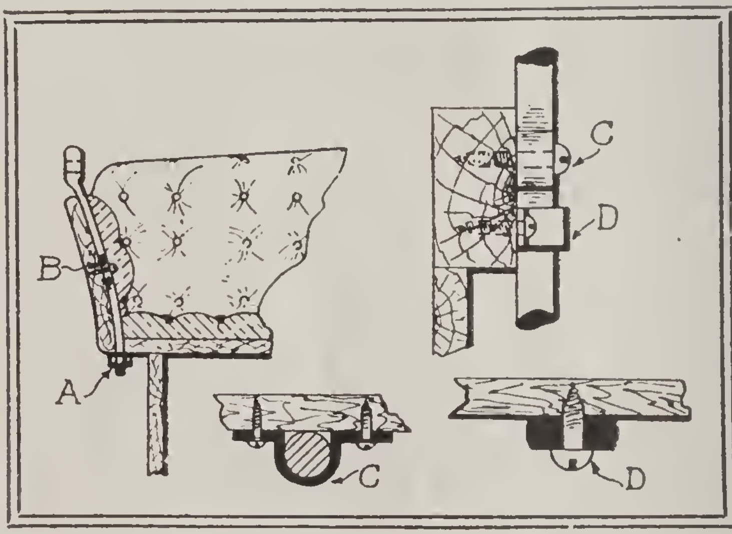


Fig. 22
Anchoring Cape Cart Hood Irons

provided, after a body has been removed for repairs; the washers being more apt to stick to the body when it is removed, and drop off unnoticed before same is replaced.

Anti-Freezing Mixtures. If a solution of alcohol and water is used, the best results will be obtained by having it just strong enough to stand the lowest temperature to which it is likely to be subjected in the climate where it is to be used.

The reason for this is that the alcohol evaporates out from the solution, and the stronger the solution, the more there is to evaporate, the easier it evaporates, and the greater the influ-

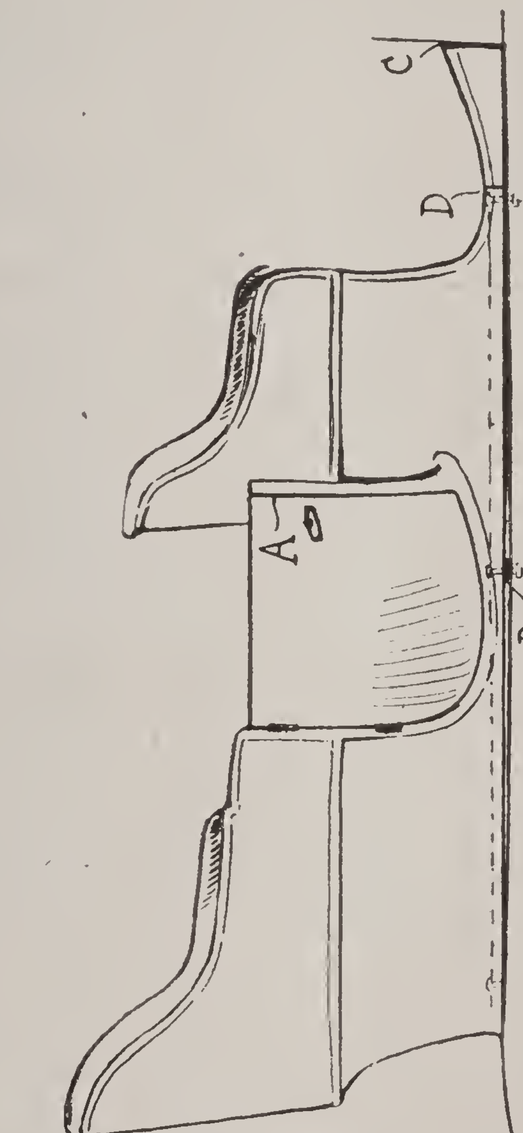


Fig. 23

ence of this evaporation upon the solution left.

The diagram shown in Fig. 21 indicates the freezing points of various solutions of denatured alcohol, also of wood alcohol. From this diagram a solution may be selected which will

stand any temperature from 50° below zero to 40° above.

Other solutions may be made with calcium chloride (common salt), also the salts known as potassium carbonate. These with water form a solution that will stand zero temperatures, but are not available where lower temperatures are common.

Aprons. The vital parts of an automobile mechanism, particularly the engine and the change speed gear, are protected by some sort of pan or apron under the car. In most cities aprons are required by law, in order to prevent the surplus oil from dropping on the pavement under the car. Leather and canvas aprons have been used in the past, but they have been largely superseded by sheet metal aprons. Most of these metal pans are simply thin sheet steel or aluminum, riveted or otherwise attached to the side sills. In a few instances, however, the steel pan is made to constitute a web, integral with the side sills, and made, of course, of the same piece of sheet steel stock.

TABLE 6.

AREAS AND CIRCUMFERENCES OF CIRCLES FROM 0.05 TO 10.0, ADVANCING BY $\frac{1}{20}$ OF ONE INCH.

Diam.	Area	Circum.	Diam.	Area	Circum.
.05	.0019	.16	2.05	3.30	6.44
.10	.0078	.31	2.10	3.46	6.59
.15	.017	.47	2.15	3.63	6.75
.20	.031	.63	2.20	3.80	6.91
.25	.049	.78	2.25	3.98	7.07
.30	.070	.94	2.30	4.15	7.22
.35	.096	1.09	2.35	4.34	7.38
.40	.12	1.26	2.40	4.52	7.54
.45	.16	1.41	2.45	4.71	7.69
.50	.19	1.57	2.50	4.91	7.85
.55	.24	1.73	2.55	5.11	8.01
.60	.28	1.88	2.60	5.31	8.17
.65	.33	2.04	2.65	5.56	8.32
.70	.38	2.19	2.70	5.72	8.48
.75	.44	2.36	2.75	5.94	8.64
.80	.50	2.51	2.80	6.16	8.79
.85	.57	2.67	2.85	6.38	8.95
.90	.64	2.83	2.90	6.60	9.11
.95	.71	2.98	2.95	6.83	9.27
1.00	.78	3.14	3.00	7.07	9.42
1.05	.86	3.29	3.05	7.31	9.58
1.10	.95	3.46	3.10	7.55	9.74
1.15	1.03	3.61	3.15	7.79	9.89
1.20	1.13	3.77	3.20	8.04	10.05
1.25	1.23	3.93	3.25	8.29	10.21
1.30	1.33	4.08	3.30	8.55	10.37
1.35	1.43	4.24	3.35	8.81	10.52
1.40	1.54	4.39	3.40	9.08	10.68
1.45	1.65	4.56	3.45	9.35	10.84
1.50	1.77	4.71	3.50	9.62	10.99
1.55	1.89	4.87	3.55	9.89	11.15
1.60	2.01	5.03	3.60	10.18	11.31
1.65	2.14	5.18	3.65	10.46	11.47
1.70	2.27	5.34	3.70	10.75	11.62
1.75	2.40	5.49	3.75	11.04	11.78
1.80	2.54	5.65	3.80	11.34	11.94
1.85	2.69	5.81	3.85	11.64	12.09
1.90	2.84	5.97	3.90	11.94	12.25
1.95	2.99	6.13	3.95	12.25	12.41
2.00	3.14	6.28	4.00	12.57	12.57

TABLE 6—CONTINUED.

Diam.	Area	Circum.	Diam.	Area	Circum.
4.05	12.88	12.72	6.25	30.68	19.63
4.10	13.20	12.88	6.30	31.17	19.79
4.15	13.53	13.04	6.35	31.67	19.95
4.20	13.85	13.19	6.40	32.17	20.11
4.25	14.19	13.35	6.45	32.67	20.26
4.30	14.52	13.51	6.50	33.18	20.42
4.35	14.86	13.66	6.55	33.69	20.58
4.40	15.20	13.82	6.60	34.21	20.73
4.45	15.55	13.98	6.65	34.73	20.89
4.50	15.90	14.14	6.70	35.26	21.05
4.55	16.25	14.29	6.75	35.78	21.20
4.60	16.62	14.45	6.80	36.32	21.36
4.65	16.98	14.61	6.85	36.85	21.52
4.70	17.35	14.76	6.90	37.39	21.68
4.75	17.73	14.92	6.95	37.94	21.83
4.80	18.09	15.08	7.00	38.48	21.99
4.85	18.47	15.24	7.05	39.04	22.15
4.90	18.86	15.39	7.10	39.59	22.30
4.95	19.24	15.55	7.15	40.15	22.46
5.00	19.63	15.71	7.20	40.71	22.62
5.05	20.03	15.86	7.25	41.28	22.78
5.10	20.43	16.02	7.30	41.85	22.93
5.15	20.84	16.18	7.35	42.43	23.09
5.20	21.23	16.34	7.40	43.01	23.25
5.25	21.65	16.49	7.45	43.59	23.40
5.30	22.06	16.65	7.50	44.18	23.56
5.35	22.48	16.81	7.55	44.77	23.72
5.40	22.90	16.96	7.60	45.36	23.88
5.45	23.33	17.12	7.65	45.96	24.03
5.50	23.76	17.28	7.70	46.57	24.19
5.55	24.19	17.44	7.75	47.17	24.35
5.60	24.63	17.59	7.80	47.78	24.50
5.65	25.07	17.75	7.85	48.39	24.66
5.70	25.52	17.91	7.90	49.02	24.82
5.75	25.97	18.06	7.95	49.64	24.97
5.80	26.42	18.22	8.00	50.26	25.13
5.85	26.88	18.38	8.05	50.89	25.29
5.90	27.34	18.54	8.10	51.53	25.43
5.95	27.80	18.69	8.15	52.17	25.60
6.00	28.27	18.85	8.20	52.81	25.76
6.05	28.75	19.01	8.25	53.46	25.92
6.10	29.22	19.16	8.30	54.11	26.07
6.15	29.70	19.32	8.35	54.76	26.23
6.20	30.19	19.48	8.40	55.42	26.39

TABLE 6—CONTINUED.

Diam.	Area	Circum.	Diam.	Area	Circum.
8.45	56.08	26.55	9.25	67.20	29.06
8.50	56.74	26.70	9.30	67.93	29.22
8.55	57.41	26.86	9.35	68.66	29.37
8.60	58.09	27.02	9.40	69.39	29.53
8.65	58.76	27.17	9.45	70.14	29.69
8.70	59.45	27.33	9.50	70.88	29.84
8.75	60.13	27.49	9.55	71.63	30.00
8.80	60.82	27.65	9.60	72.38	30.15
8.85	61.51	27.80	9.65	73.14	30.32
8.90	62.21	27.96	9.70	73.89	30.47
8.95	62.91	28.12	9.75	74.66	30.63
9.00	63.62	28.27	9.80	75.43	30.79
9.05	64.33	28.43	9.85	76.20	30.94
9.10	65.04	28.59	9.90	76.98	31.10
9.15	65.76	28.74	9.95	77.76	31.26
9.20	66.48	28.90	10.00	78.56	31.42

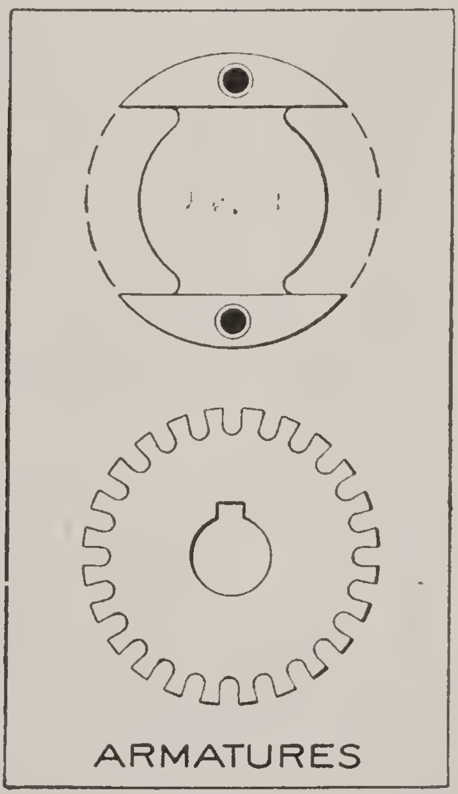


Fig. 24

Armatures, Slotted and Shuttle Types of. An armature is the rotating part of a dynamo or electric motor which generates electricity or develops power.

The armature shown at top of Figure 24 is known as the Siemen's H or shuttle type and is the simplest form of wire-wound armature known. The current given by this form of armature is of the alternating type and is converted into a direct-current, when desired, by means of a two-part commutator on the armature shaft.

The slotted type of armature shown at the bottom of Figure 24 has a more intricate system of winding than the shuttle type just described. It has, however, a far greater electrical efficiency and gives off a steadier current than the shuttle type. It is the form most generally used for automobile and street railway motors. Like the shuttle type of armature, the current generated by the slotted type of armature is alternating, and is converted into a direct current by means of a commutator of very complicated form.

Asbestos. Asbestos is principally a hydrous silicate of magnesia, that is, silicate of magnesia combined with water. When harsh fibre is analyzed it is found to contain less water than the soft fibre. If soft fibre be heated to a temperature which will evaporate a portion of the combined water, there results a substance so brittle that it may be crumbled between the thumb and finger.

There is evidently some connection between the consistency of the fibre, and the amount of water in its composition.

Assembling a Car. In assembling the car the engine had best be put together first. When putting the pistons in their respective cylinders see that the splits or joints in the piston rings are not in line, but are spaced evenly around the piston. See that all parts are thoroughly clean and that no grit, or stray strands of waste happen to be caught on any projection. All nuts and bolts should be screwed tight and the jaws of the wrench should be properly adjusted to them, that the corners of the nuts and cap screws may not be rounded off. Insert the cotter pin after each nut has been screwed home. In joints where packing is required the old packing may be used if it is in good shape. Joint faces should, of course, be perfectly clean. A stout grade of manila wrapping paper soaked in linseed oil will make an excellent packing for crankcase and other joints having a good contact surface.

While the engine is being reassembled it will be found advantageous to check up the valve timing. To do this, turn the fly-wheel until the inlet valve plunger of No. 1 cylinder just touches the lower end of its valve stem. At this point the line on the fly-wheel indicating "Inlet No. 1 Open" should coincide with the pointer on the engine base. If the contact between the valve stem and the plunger is made before the mark on the fly-wheel lines up with the pointer, the valve opens too early. In most cars the adjustments may be made by the screw cap and

lock-nut on the plunger. As the valve stems are lowered by repeated grindings of the valves, the plungers require adjustment occasionally to compensate for this movement. Insert a piece of paper between plunger and valve stem, and by lightly pulling on the paper the time of contact and the moment of release may be determined to a nicety. When the paper is held tightly, a good contact is assured, and the moment the paper becomes loose and can be moved about, the contact is broken. In many cars the reference or index mark on the engine bed is omitted; in this case the markings on the flywheel must be brought directly to the top. The other inlets and the exhaust valves should then be similarly checked up and adjusted.

Most cars base the valve setting on a 1-32 inch clearance space between valve stem and plunger rod when the valve is closed. This may be taken as the minimum amount, and should not be increased. A larger amount of clearance will cause the exhaust valve to open too late, and, the exploded gases not being entirely expelled, the power of the motor will be impaired. This clearance is necessary to allow for the expansion of the valve stem when it becomes heated.

Too much stress cannot be laid on the necessity of going about the work in an orderly and methodical manner. A mechanic who leaves parts lying about carelessly will rarely be found a good one, and certainly he is not a proper

model for the amateur to copy. With the proper circumspection, then, and with a little "horse sense" in applying the directions to his particular make of car, the amateur owner should have no difficulty in making a good job of over-

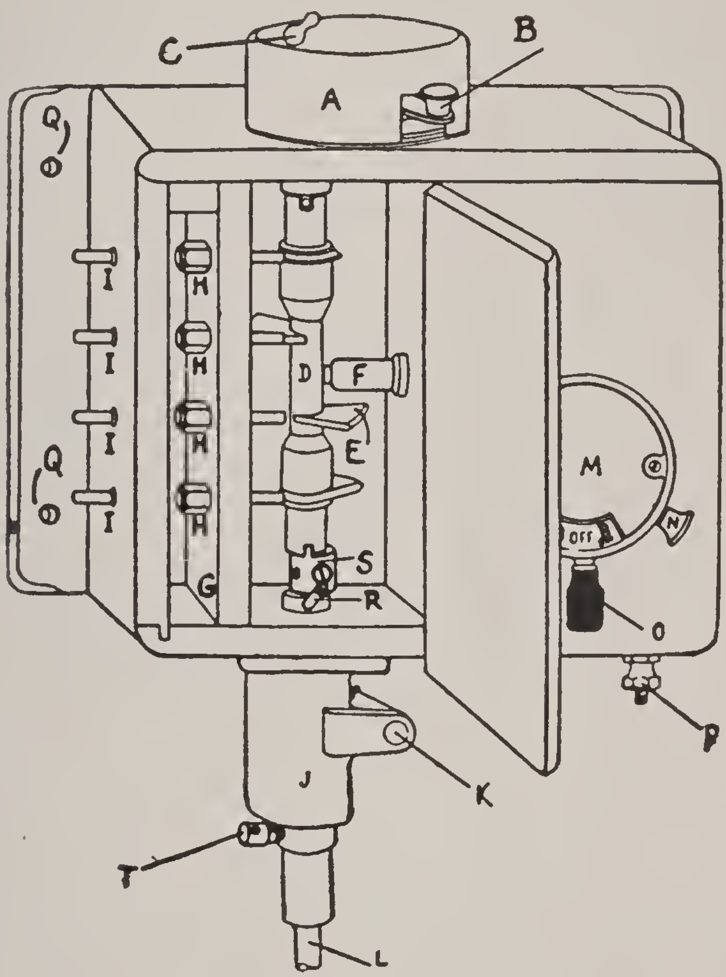


Fig. 25
Atwater-Kent Spark Generator

hauling, thus bettering the condition of his machine and at the same time acquiring a valuable stock of knowledge for the future.

Atwater-Kent Spark Generator. This device is designed to draw from a battery, as nearly as possible, only the electrical energy necessary

to ignite the charge, and to keep the batteries until the energy remaining in them is too small to produce an effective spark. Its principal constituent parts are, a jump-spark coil and condenser, a primary contact maker, the time of which may be advanced or retarded, and a high tension distributer. Its distinguishing features are—

a. But one spark is made for each ignition.

b. The primary contact, rupture of which produces the spark, is exceedingly brief, no longer in fact than is actually required to build up the magnetism in the core of the spark coil.

c. The duration of this contact is independent of the engine speed in the same way that the contact of the ordinary coil vibrator is.

d. Contact is made and broken mechanically through a shaft driven by the engine, consequently a spark may be obtained from a battery that is too weak to operate a vibrator. The mechanism by which the instantaneous primary contact is produced is similar to a snap contact produced by a small spring-controlled hammer pulled out of position by a ratchet on the shaft. The ratchet has as many teeth as there are cylinders, and runs at the camshaft speed. When used with a two-cycle engine, it runs at the crankshaft speed if there are four cylinders. If there are two cylinders, it runs at half the engine speed and the ratchet has four teeth. The ordinary commutator is not used in connection with it, but a driving connection must be made

from the crankshaft or camshaft to the vertical shaft of the spark generator itself, which is mounted on the back of the dashboard.

The different parts of the Atwater-Kent spark generator are shown in Fig. 25, in which A is a cover on contact maker; B, starting button for starting engine on spark; C, wing nut for holding cover on contact maker; D, distributer; E, distributer blade (there are four

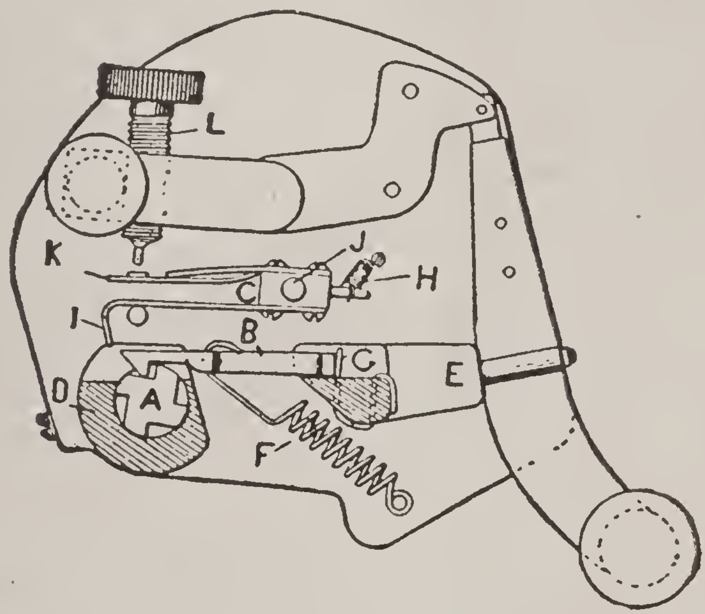


Fig. 26

of these, only one being lettered); F, secondary brush holder (inside this brush holder is a brush, bearing by spring tension against distributer); G, distributer board; H, H, H, H, secondary binding-posts; I, I, I, I, cylinder cutouts; J, spark advancing mechanism; K, spark advancing shaft; L, driving shaft; M, switch; N, switch plug; O, switch handle; P, carbon battery binding-post; Q, Q, holes for bolts to hold spark generator on dash (two of these on

other side are not shown); R, oil tube; S, clamping collar for setting time of spark; T, oil cup.

The essential feature of the Atwater-Kent generator is the contact maker shown in Figs. 26-27.

The plan is show in Fig. 26, where the following moving parts are shown: A, the shaft; B, the snapper, and C, the pivoted contact arm. The shaft is provided with four milled notches

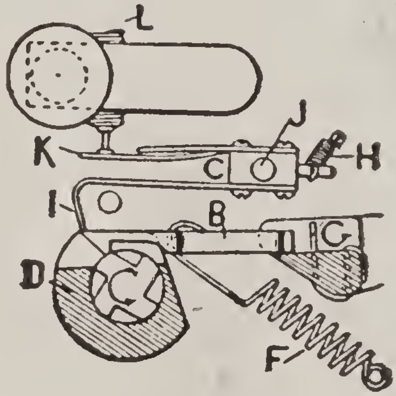


Fig. 27
Atwater-Kent Contact Maker

(or six for a six-cylinder engine), forming a ratchet which engages the claw at the end of the snapper. This latter is a light, tempered steel piece which is guided by slots in the bronze base E D, and held against a stop G made of spring wire by means of a spring F, when released from engagement with the notches on the shaft. Contact arm C is also held normally in the position shown by the tension of the coil spring H.

The shaft, turning in a counter-clockwise direction, draws the snapper into position, the

claw of the snapper when released riding up on the rounded part of the shaft, Fig. 27, thus acting as a wedge between the shaft and the steel hook I of the contact arm which is pivoted at J. The contact arm is thus oscillated to produce contact between a platinum point on a flat copper spring K, and the insulated stationary contact screw L. As the snapper continues its motion it releases I, permitting the contact arm to rebound and break contact. The snapper comes to rest in its normal position as in Fig. 26, and the contact arm resumes its position resting against the stop. The operation is repeated when the snapper engages the next tooth of the ratchet.

Autogenous Welding. This process consists of welding, or, more correctly speaking, melting together metals by means of the oxyacetylene flame, the temperature of which almost rivals that of the electric arc, being 6,300 degrees Fahrenheit. The facility with which it can be handled as compared with most other methods makes its commercial application comparatively simple. The possibilities attendant upon the use of a flame of such high temperature can be realized when it is remembered that the melting point of steel is about 2,570 degrees and that of platinum, one of the most refractory metals, is only 3,227 degrees Fahrenheit. Its chief field of usefulness is in combining such metal parts as would ordinarily be riveted, in welding small parts together, in repairing bro-

ken or defective castings and for cutting metals of any nature or size that occasions demand.

As it is possible to unite many dissimilar metals, and with a heat so localized that neighboring parts are not affected, autogenous weld-

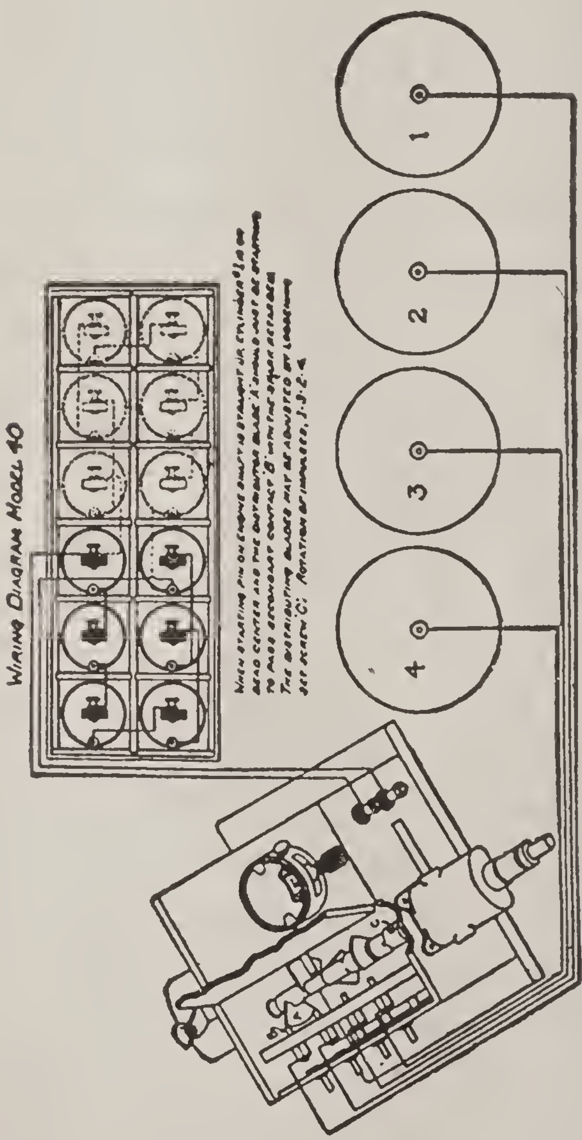


Fig. 28

ing has already found an extensive application in motor car repair work. Broken crankcases or other parts can be united and made practically as strong as new. The method of holding the pieces of a broken aluminum case, for exam-

ple, is to clamp them into position temporarily while clay is packed around the parts and heated sufficiently to drive out the moisture,

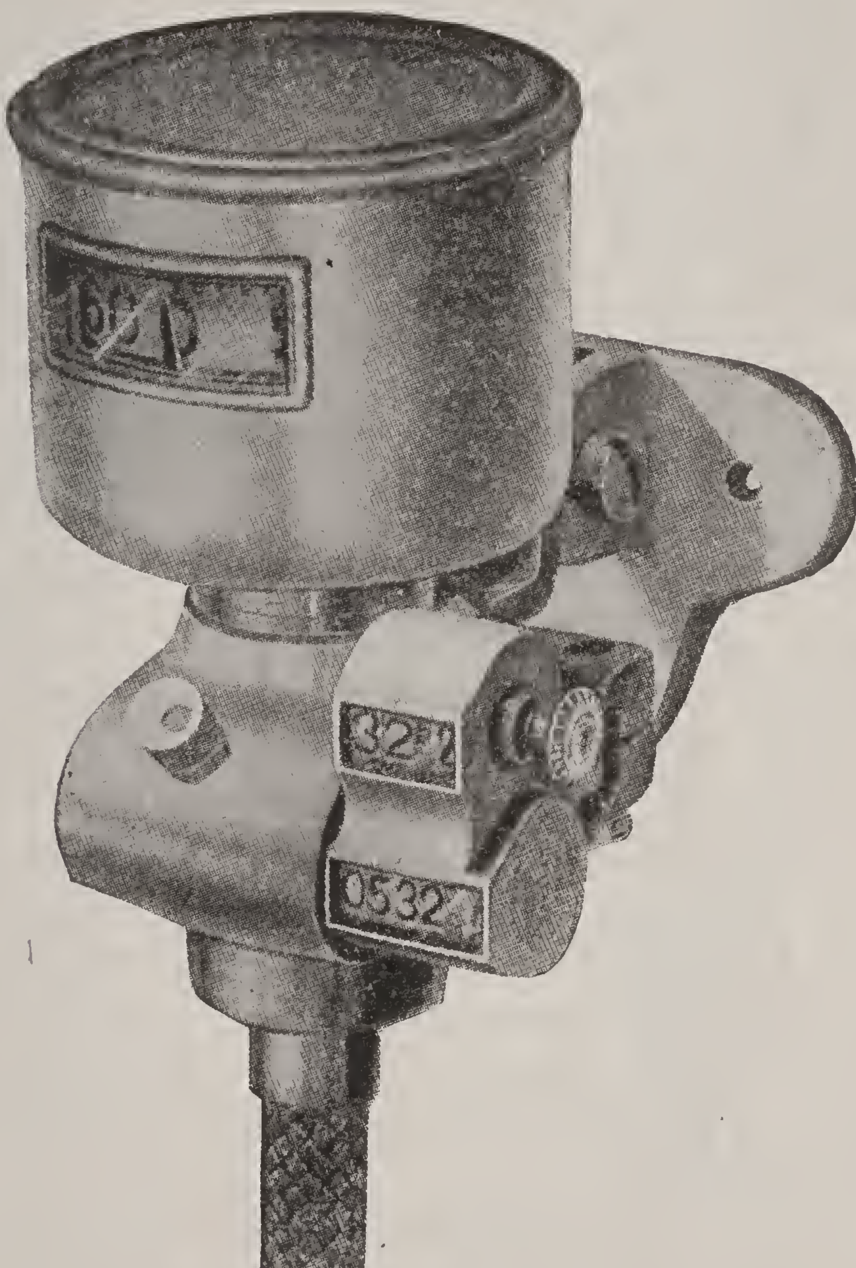


Fig. 28a
Auto-Meter

thus forming a solid support for the parts as well as a kind of mould. A series of holes are usually drilled at the crack, or the edges of the

pieces are roughly beveled so, as previously explained, the metal can be built up from the bottom. In some instances lugs or peculiar shaped projections may have been completely worn off or destroyed when it becomes necessary to build up new ones with additional metal. In repairing a cracked waterjacket, after the edges of the crack have been prepared, it is customary to use copper instead of iron wire for the filling metal as it flows at a lower temperature and adheres very positively. In case there is danger of warping, due to local expansion, the entire cylinder is heated before operating upon it.

Auto-Meter. Figures 28a and 28b show an outside view and a cross-section of the Auto-Meter which illustrates its internal mechanism. C is the magnet which revolves freely on ball bearings. It is not connected in any way with the indicating dial. The latter is suspended in front of the magnet and a partition separates them, precluding the possibility of air affecting it. The dial is mounted on a pivot, the ends of which ride in sapphire bearings. The pivot ends are carefully ground and lapped with diamond dust.

The hair spring H holds the dial to zero point. The magnet when revolving has a tendency to draw the dial in the direction of its revolution. The hair spring opposes this tendency. The greater the rapidity of the magnet's revolution, the greater the displacement of the dial, and

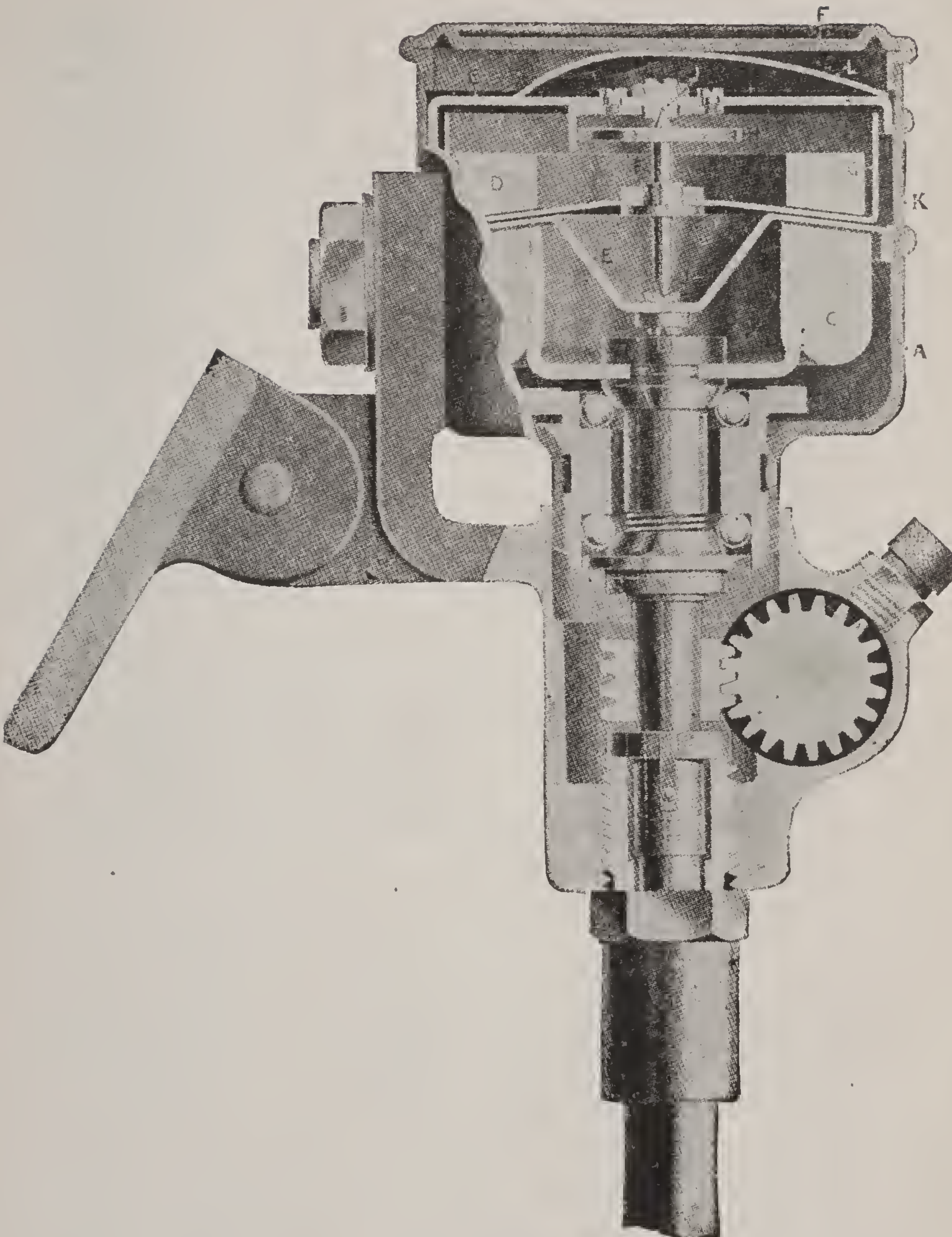


Fig. 28b
Cross-Section of Auto-Meter

when the speed of the magnet doubles, the displacement is doubled. In a word, the displacement increases proportionately as the speed increases, so that even reading over the entire

scale results. The length of the dial is practically six inches. The action of the magnet on the dial being direct there is nothing intervening to cause a variation in its reading.

The worm, driven by the same shaft that drives the magnet C, operates the worm gear which is connected directly to the odometer. This odometer can be removed in a moment, if necessary.

Driving the odometer, as above described, obviates the danger of knocking it off, which is likely to occur were it mounted on the axle. Mounted on the dashboard where it can be tilted to any angle to accommodate the vision of the motorist, it is possible for him to determine the distance covered at any stage of the journey.

The magnet is so shaped that it will not weaken and affect the reading of the instrument.

The internal parts of the Auto-Meter are gold plated. This is not done to please the eye of the user, for he never sets eye on these parts, but to add to their durability. It is a contribution to cleanliness and a preventive of corrosion. The ball cups and cones are carefully made from the best steel and thoroughly tested before used. To make assurance doubly sure, the instrument is tightly sealed and becomes absolutely dustproof.

The instrument will show accurately a speed of one mile per hour and many an automobile owner has been surprised to learn that his aver-

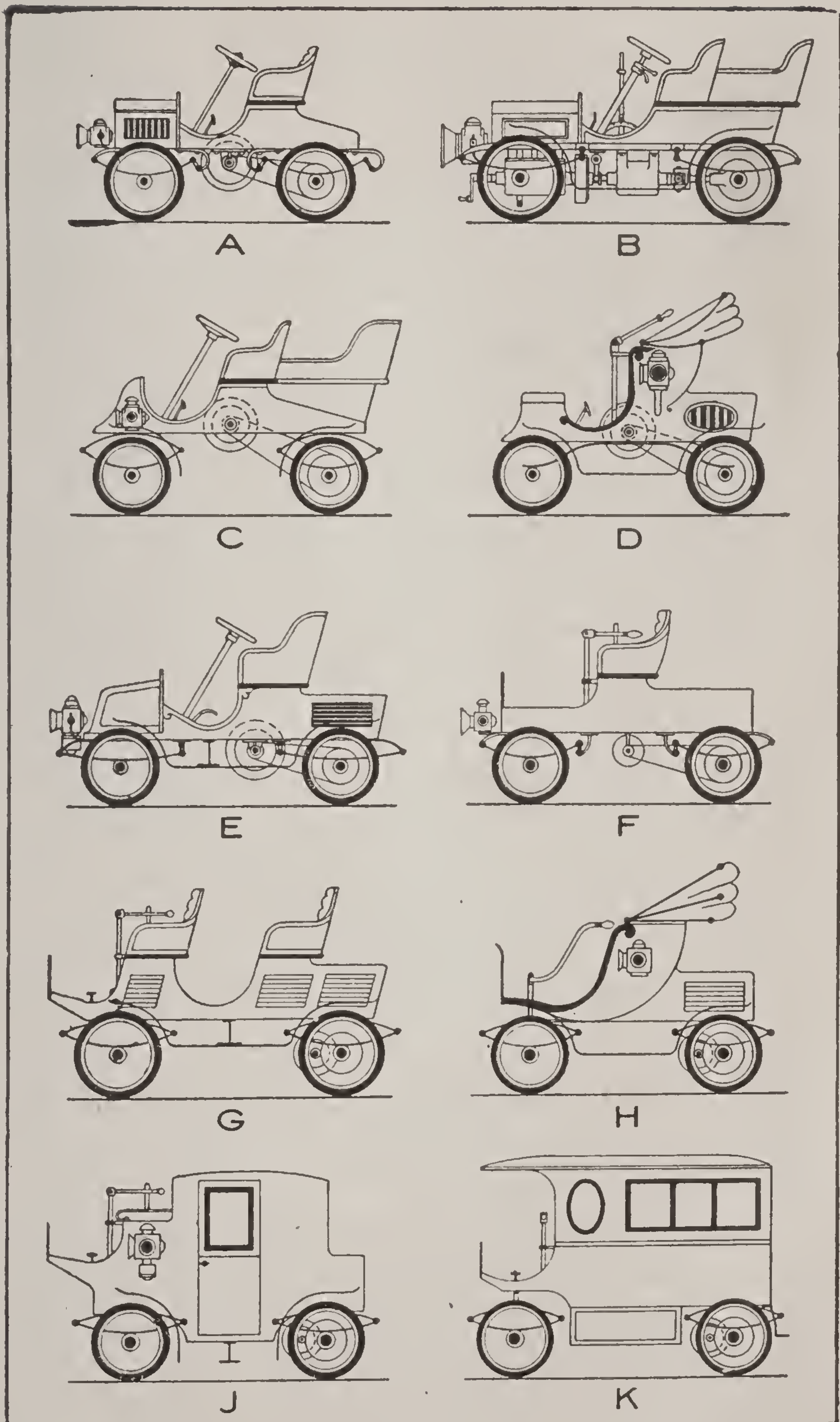


Fig. 29
Typical American Gasoline and Electric Automobiles
See Automobiles, Typical American

age speed while traveling through the city streets has been from fifteen to twenty-five miles per hour.

Automobile. A self moving vehicle, especially a carriage driven by steam, gasoline, electric, or other power, by means of a motor borne on the vehicle.

Automobile Body—Care of—A highly finished body should never be wiped off dry, as it is impossible to do this and not scratch the polished surface. The best and quickest way is to turn a hose on it and then while still wet wipe off with a piece of chamois or a soft cloth. Waste might be used if of a selected grade, but the ordinary cheap kind must never be utilized, as it contains small sticks and other hard substances which will scratch the varnish.

Automobiles—Types of. Fig. 29 illustrates the various types of American Automobiles, both gasoline and electric, designated as follows:

Gasoline. A—Runabout. B—Touring car. C—Light car with detachable Tonneau. D—Stanhope. E—Roadster.

Electric. F—Runabout. G—Park trap. H—Phaeton. J—Brougham. K—Depot-bus or light delivery wagon.

Axles. So far it has not been found practical to combine the tractive, and steering functions of an Automobile in one set of wheels and axle. Therefore it is necessary to use a rigid front axle with knuckle jointed spindles, for steering purposes, and utilize the tractive power of the rear

wheels only to propel the car. Some of the earlier forms of steering axles had the wheel pivots inclined so as to bring the projection of the pivot axis in line with the point of contact of the wheel with the ground, but as such constructions have not proved satisfactory they have in most cases been abandoned.

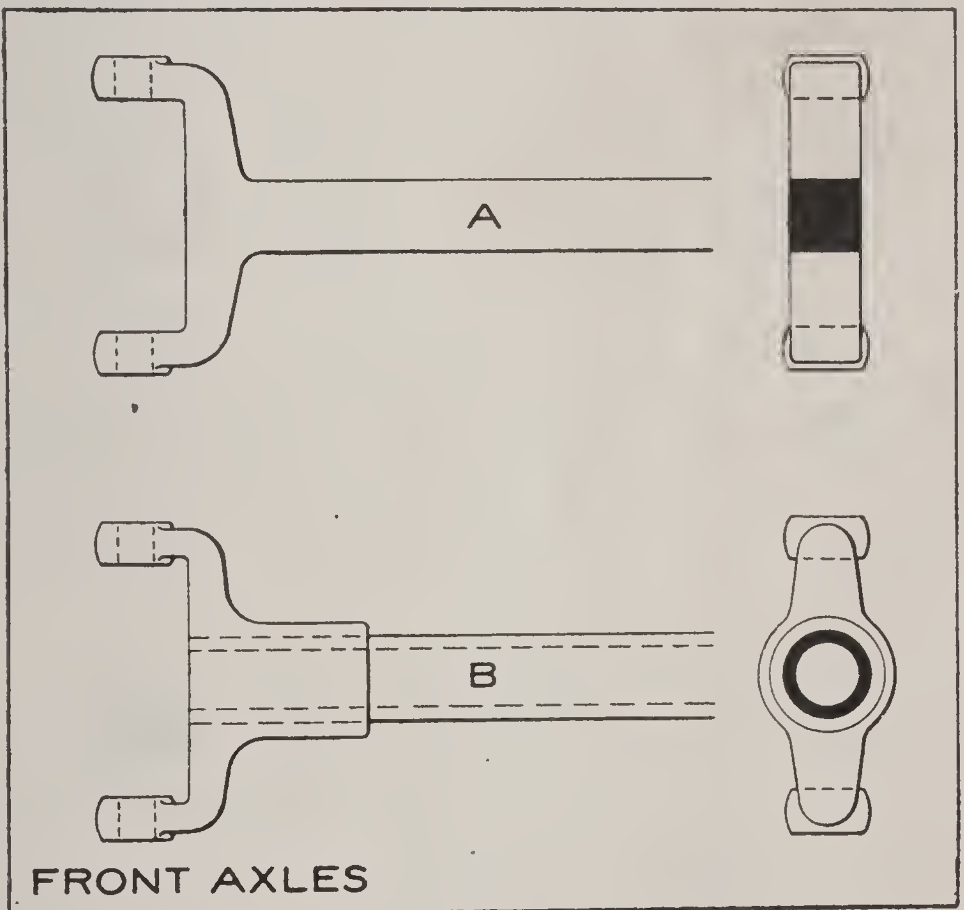


Fig. 30

Dead Axle. A dead axle is an axle which carries weight only.

Floating Axle. A special type of live axle in which the shaft that turns the wheels is independent of the axle proper, and may be removed without affecting the axle's weight carrying capacity.

Front Axles. Figures 30 and 31 show four styles of front axles with steering-pivot ends: A shows a solid axle of square section, with the steering-pivot jaws and axle proper, of a single forging—B represents an axle of tubular cross-section with the steering-pivot jaws bored

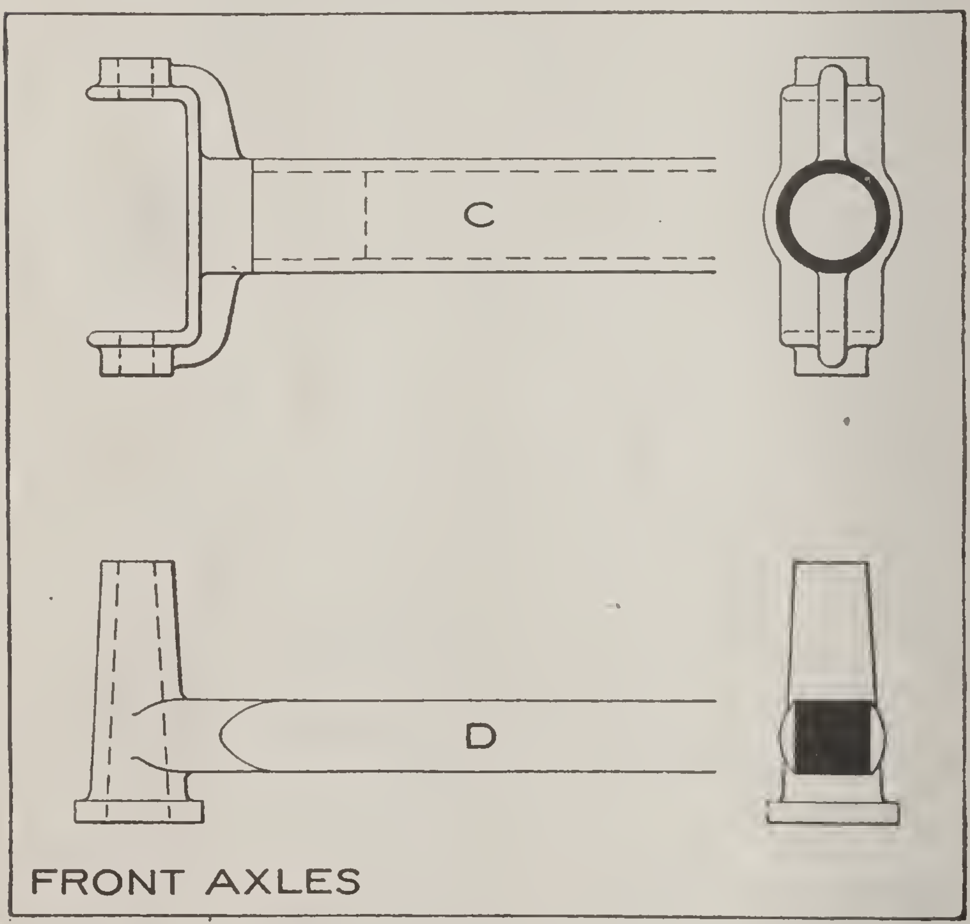


Fig. 31

out to receive the tubular axle which is firmly brazed therein—C shows another style of tubular axle, in which the steering-pivot jaw ends are turned down to fit the inside diameter of the tube and are also brazed in position, while D illustrates a one-piece axle with vertical hubs

instead of jaws, which carry L-shaped steering-pivots, instead of the usual form of knuckles.

Live Axle. A live axle is any axle containing parts which turn the wheels in addition to carrying weight.

Rear Axles. A great many medium and high-powered cars have a double side-chain

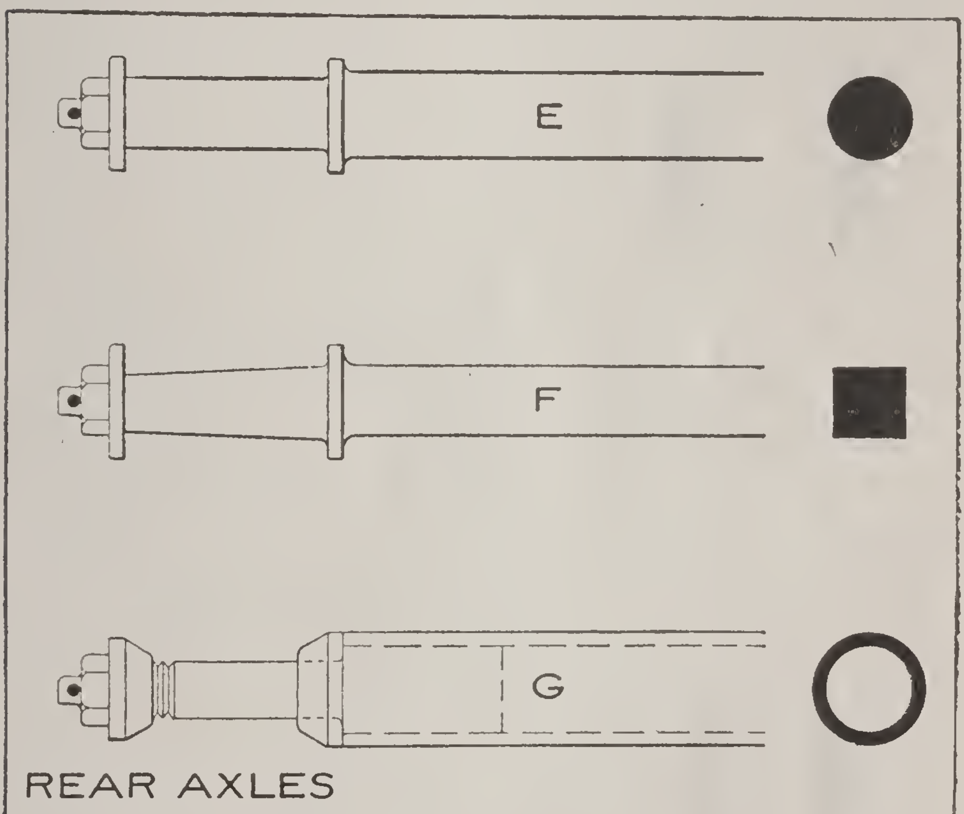


Fig. 32

drive; this necessitates free driving wheels and a rigid rear axle with this form of drive.

Figure 32 illustrates three forms of rigid rear axles for the above described form of drive: E shows a solid axle of circular section with straight spindles for hubs with plain-bearings—F, a solid axle of square section with taper spindles for plain-bearing hubs, and G an axle

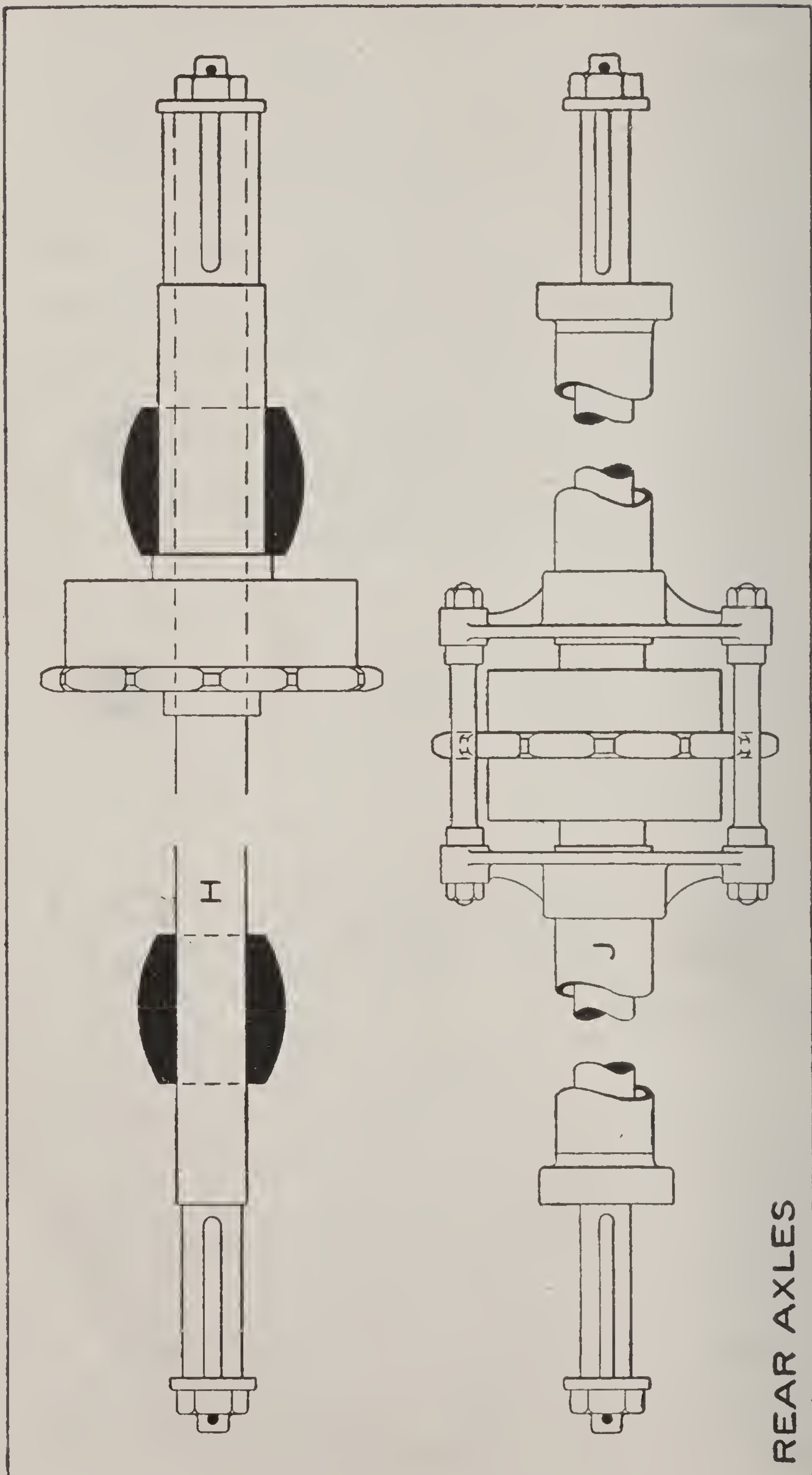


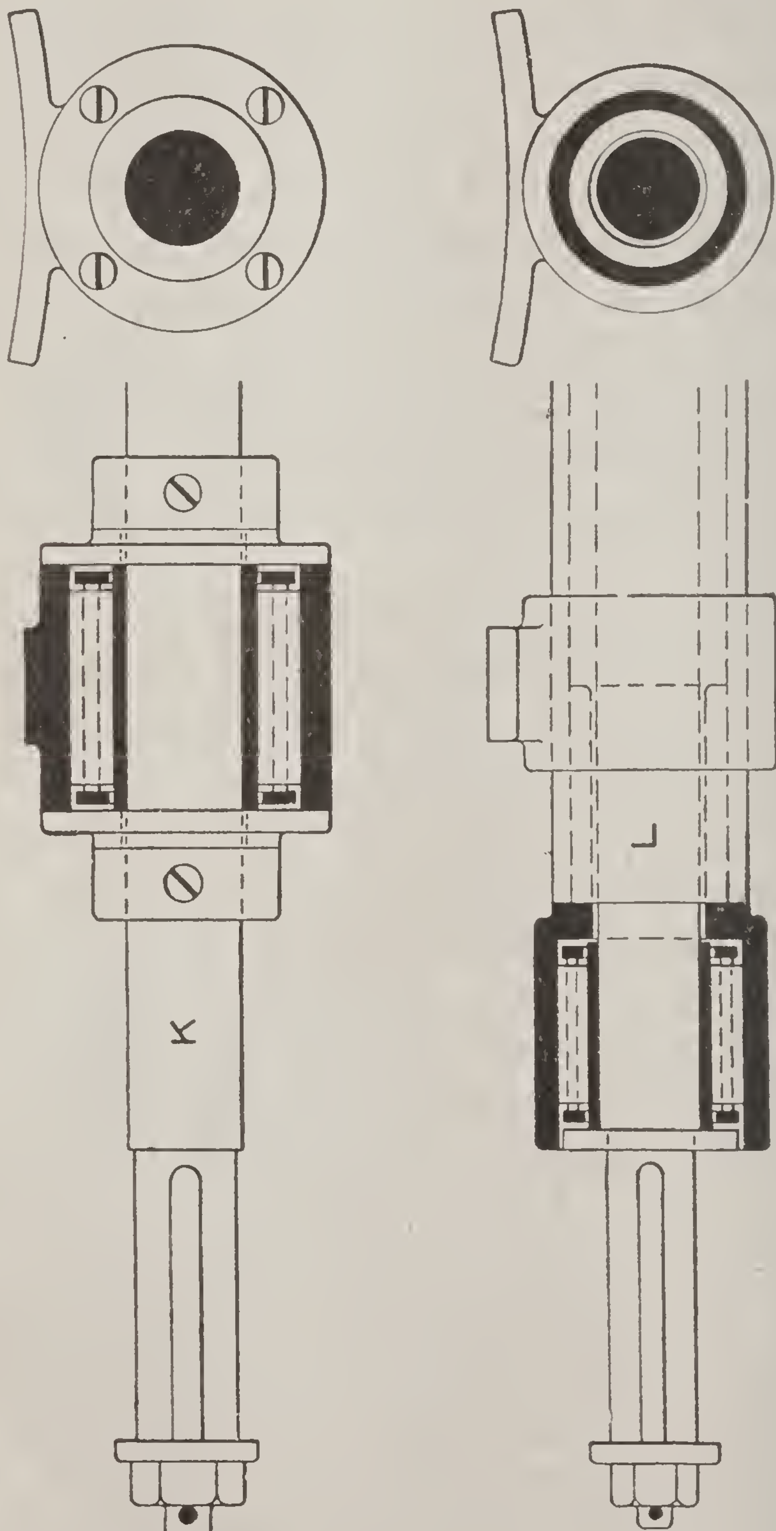
Fig. 33

of tubular section with spindles fitted for ball-bearing hubs.

Automobiles employing a single chain drive from the motor to the rear axle, generally use either a live solid rear axle with one driving wheel carried upon a loose sleeve attached to one of the gears of the differential, or a rigid tubular axle with a divided live-shaft, to the outer ends of which the driving wheels are keyed. Axles of these types are shown in Figure 33: H illustrates a solid live rear axle with plain-bearings and sprocket on the differential gear case.

Normally both the axle and the sleeve rotate in unionism, but on the car departing from a straight course or turning a corner, the sleeve will move faster or slower than the axle, according to the direction of curvature. A rigid tubular axle with a divided live driving shaft is shown at J; the tubular portions of the axle have spiders on their inner ends, which are connected around the differential gear and sprocket by means of shoulder-studs with nuts, as shown in the drawing. The type of axle illustrated at H may have either plain or roller-bearings, while the type shown at J is usually constructed with four sets of ball-bearings, two sets at the outer ends of the tubular axle and two sets near the center, one on either side of the differential case, within the hubs of the spiders.

In Figure 34, K and L show respectively a live solid rear axle and a rigid tubular axle,



ROLLER BEARING AXLES

Fig. 34

equipped with roller-bearings. The spring lugs form part of the roller-bearing boxes of the live axle, while they are usually brazed to the tubular axle near its outer ends.

A rigid tubular axle with ball-bearing live driving shaft is illustrated in Figure 35, the ball-cup or race is adjustable by means of a hexagon upon its outer extension in the rear of the hub of the wheel and is held securely in position

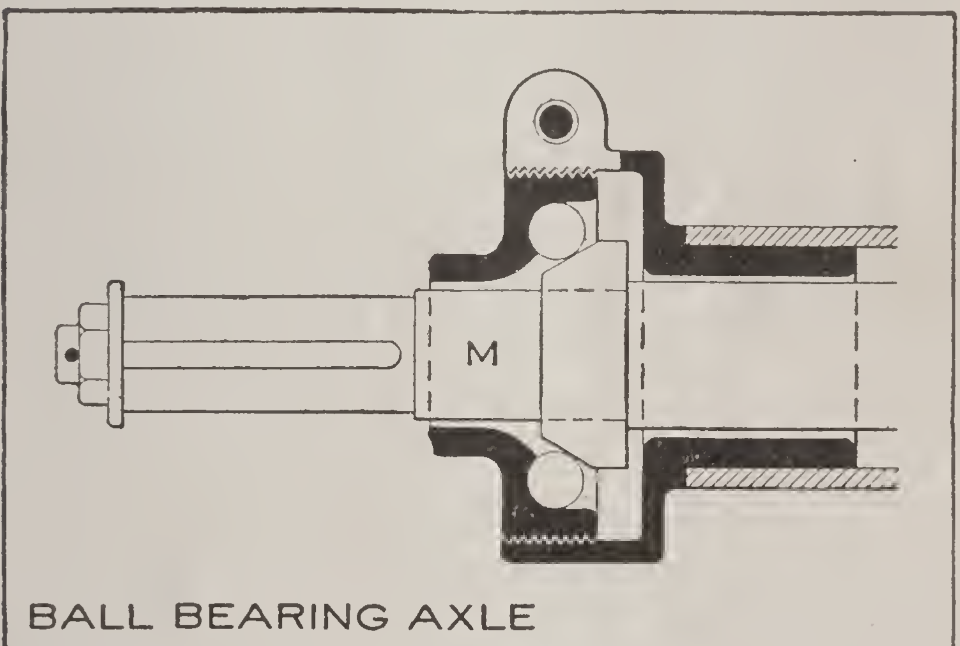
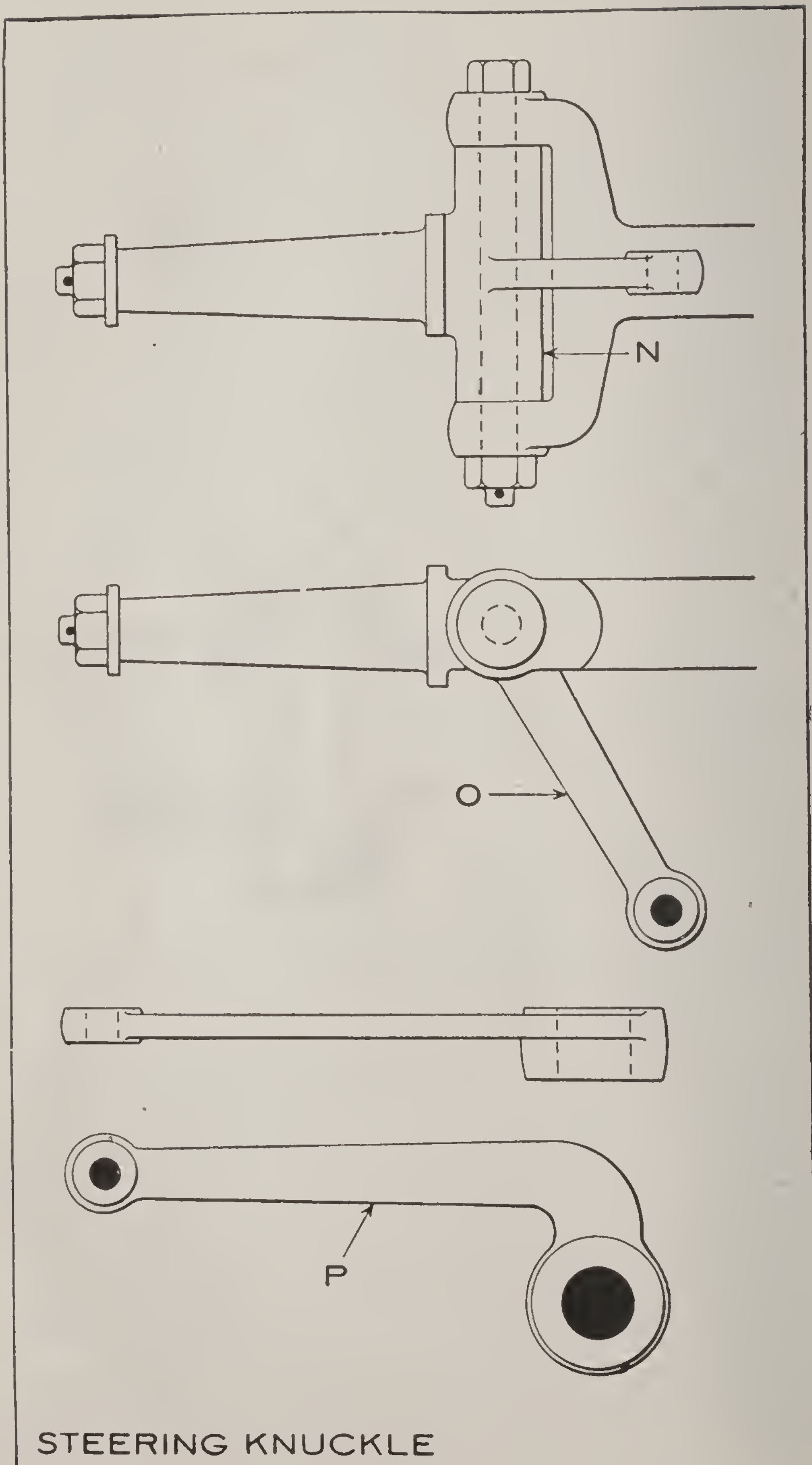


Fig. 35

and prevented from turning by means of the clamping device shown on the upper portion of the bearing. No separate adjustments for the inner two sets of ball-bearings are necessary, as the teeth of the spur gears of the differential which are keyed to the inner ends of the divided driving shaft, being free to slide upon themselves, allow the shafts M to have a slight longitudinal movement within the axle tube, thus



STEERING KNUCKLE

Fig. 36

taking up the wear of each pair of ball-bearings with a single adjusting mechanism.

STEERING KNUCKLES. In order to obtain ease of operation and secure the shortest turning radius with the least movement of the steering wheel or lever, the knuckle of the steering pivot should be as close to the center of the wheel as is possible. It is also cf great importance that the steering knuckles should be as heavy as is practically consistent with the size and weight of the car for which they are intended. If this imporant point be neglected, rapid wear and probable fracture of the knuckles may be looked for.

A steering knuckle with a spindle and pivot of T shape is shown in Figure 36. The spindle and pivot N and the steering arms O are usually a one-piece forging. The steering arms O are connected by means of a suitable distance rod and the steering lever P is attached to one of the pivots N by turning a shoulder upon it and pinning and brazing the steering lever and pivot hub together.

Figure 37 shows a steering knuckle with spindle and pivot of L shape. The steering arm R goes on the lower end of one pivot Q only, the other pivot having the combined steering arm and ever S on its lower end. The steering arms being detachable, the device may be operated from the right or left hand side by simply exchanging the levers R and S. The steering lever S has a ball upon its outer end to fit in the

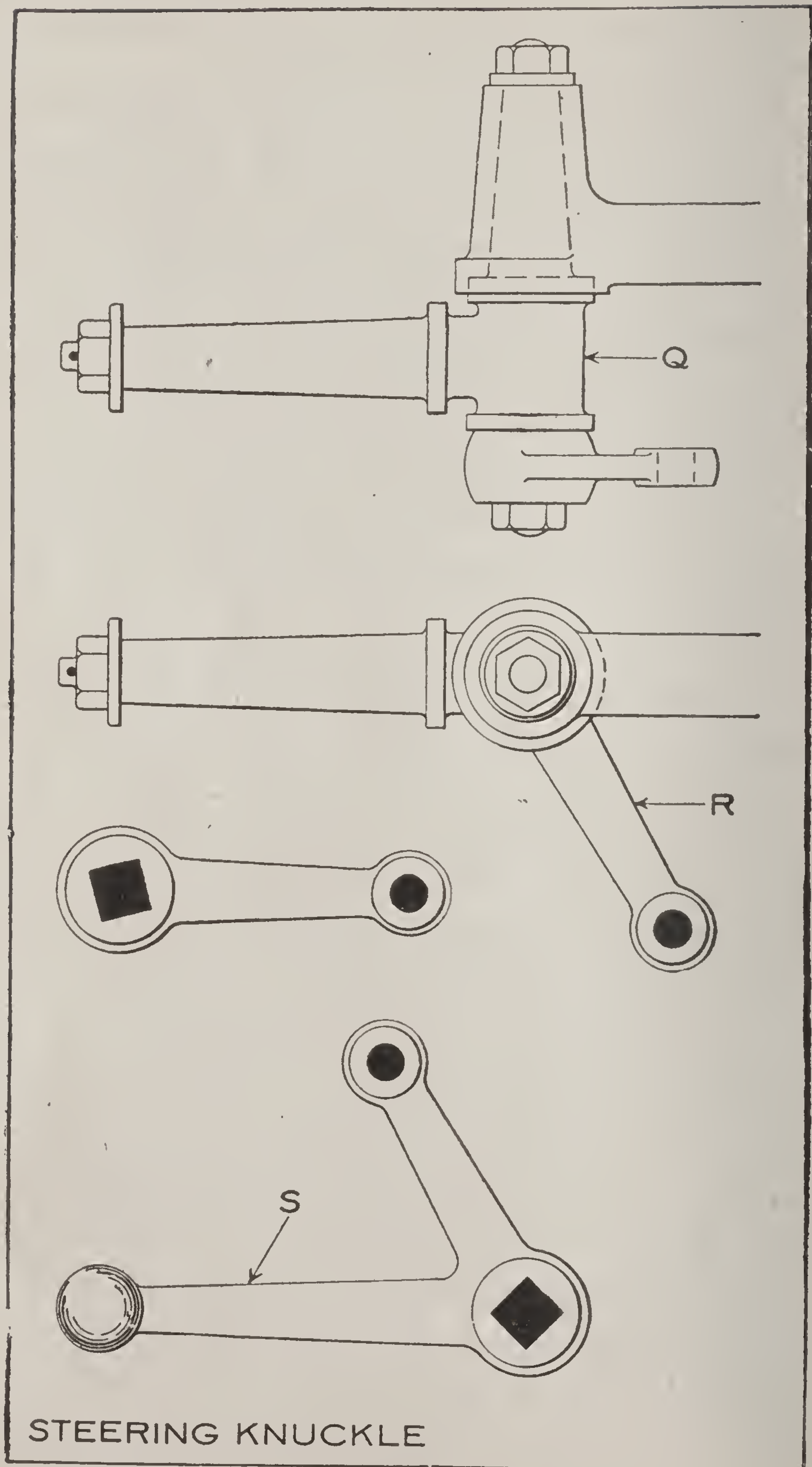


Fig. 37

socket on the connecting rod of the steering mechanism.

Backfiring, Causes of. This is a term applied to an explosion or impulse which forces the flywheel of a motor suddenly backwards, that is, in the opposite direction to its proper rotation. The term is sometimes used in connection with explosions which occur in the muffler from the ignition of an accumulation of unburned gases.

When a back kick occurs and the crank-shaft rotates in the reverse direction, that rotation must first be stopped and a rotation started in the correct direction. To stop the back kick or reverse rotation requires power, and to again start the correct rotation calls for power. The forces that stop the back kick are, the arm of the person cranking the weight of the rotating flywheel, and forcing one of the other pistons to compress the mixture. The force that starts the flywheel in the correct direction is the ex-illustrated in Fig. 38, in which the piston in No. 1 cylinder has not reached the top dead center on the compression stroke when the spark occurs and the reverse movement of the crankshaft starts. In tracing out what happens the valve locations must be considered. Both valves—intake and exhaust—in No. 1 cylinder are closed on the compression stroke and they will remain closed on the back kick stroke. Had the motor been running, No. 2 cylinder would have been going down on the explosion

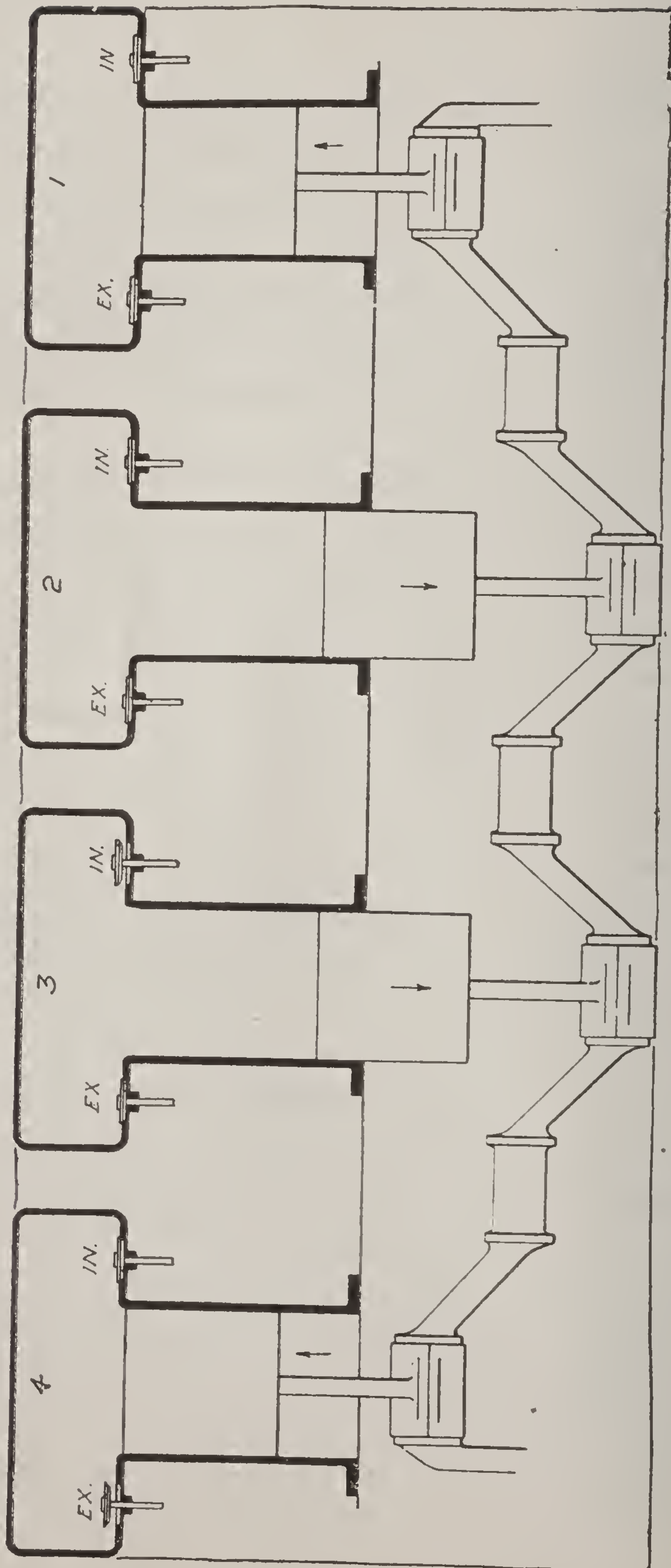


Fig. 38
Diagram Illustrating Theory of Back Firing

stroke of the piston, but as there was no previous explosion, the motor having been idle, the cylinder would be filled with mixture, with both valves closed, as they always are on the explosion stroke. The piston in this cylinder was normally going down; but, as soon as the back-fire occurred, the piston would start up and the valves remaining closed, the mixture would be compressed. This pressure would help to stop the back kick, and as soon as the power of back-kick was over the compression would start the piston down on the proper explosion stroke, which would prove of sufficient power to carry the motor past the firing point in the other cylinders. Cylinders 3 and 4 would not be factors at all, in that the piston in No. 3 would, when the back-kick occurred, be near the bottom or end of the suction stroke with the intake valve open, and when the reverse action of the piston set in it would start rising, simply driving the mixture out through the open intake valve and through the carbureter. Cylinder No. 4 was near the completion of the exhaust stroke when the back-fire started, and the exhaust valve was open. During the reverse motion caused by the back fire, the piston would start descending, the exhaust valve remaining open, exhaust gases would be drawn into the cylinder from the exhaust pipe.

Other causes of back firing are,

(1) A WEAK MIXTURE. Bearing in mind that the mixture is the fuel of the engine, and that

as in a stove, the character of the fuel influences its manner of burning, it will be evident that like poor wood, slaty coal, or other imperfect fuel, a weak mixture is a slow burner. This is point number one. Proportionate to the speed at which it is running, the motor has a certain sharply defined period of time in which it must complete each part of its cycle, if it is to operate satisfactorily. Should the parts of the cycle lap, or run over into one another, there is bound to be a hitch of some kind. The use of a very weak mixture causes just such a hitch by reason of the fact that it continues burning for some time after the completion of the part of the cycle during which it is supposed to function, i. e., the power stroke. In fact, it is still burning when the inlet valve opens to take in a fresh charge, and as its burning in the cylinder maintains considerable pressure therein, the latter, on the lift of the inlet valve, escapes through it and the carbureter with a pop. exactly similar to that of an unmuffled exhaust except that it is weaker. The remedy is more gas or less air, or sometimes both, and to find out just how much of each is required, start the motor and very gradually cut down its gasoline supply at the needle valve of the carbureter until the motor begins to miss. Then as slowly increase the supply until the motor will run steadily and without missing on the minimum opening of the needle valve. Lock the latter in place. Then speed the motor up by

opening the throttle and adjust the spring of the auxiliary intake on the carbureter until the motor is receiving sufficient air to enable it to run and develop plenty of power at all speeds.

(2) An overheated combustion chamber, due to a poor circulation of the cooling water—causing self-ignition of the charge before the proper time.

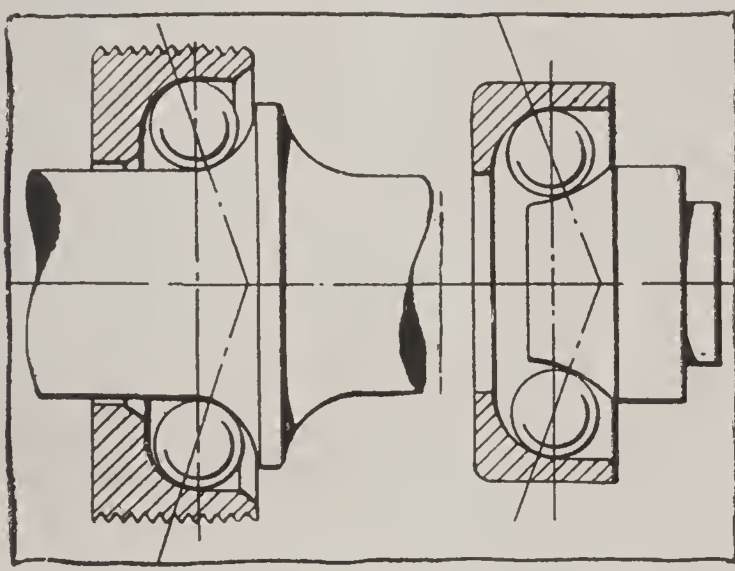


Fig. 39
Cone Bearing

(3) Advancing the ignition point too far ahead when the motor is running slowly under a heavy load—flywheel has not sufficient momentum to force the piston over the dead center, against the pressure of the already ignited and expanding gases.

(4) The presence of a deposit of carbon (soot) or a small projecting surface in the combustion chamber which may become incandescent and cause premature ignition.

Ball Bearings. Ball bearings may be broadly divided into three classes—thrust, cone and annular. Thrust bearings are those intended to sustain end thrust, and in them care must be exercised to see that the points of contact of the balls are exactly opposite, and that the grooves in which the balls run are formed to a sectional radius a little larger than that of the balls, thereby securing safe and easy movement of the balls. These grooves must be designed not only to give smooth rolling contact, but so that a measurable area of the ball's surface contacts with the race. It is also possible for a thrust bearing to act at the same time as a radial bearing, in which case, however, the four-point system must be used. In thrust bearings the balls are constantly under pressure and table 7 gives suitable loads for equal shaft diameters and revolutions for different sizes and numbers of balls:

TABLE 7.

Shaft Diameter, in inches.	Allowable Load lbs.	R.P.M.	Number of Balls	Ball Diameter in Inches
2.55	550	500	22	⅜
2.55	1,000	500	15	⅝
2.55	1,200	500	14	11/16
2.55	1,300	500	13	¾
2.55	1,600	500	12	⅞
2.55	1,800	500	10	1

The adjustable cone bearing, Fig. 39, has been used in millions of bicycles with excellent results, but under large loads has been found inadequate. A ball can roll freely only with opposite points in contact, and every third or

fourth point of contact involves more or less spinning, or sliding movement of the ball, which shortens its life, and the bearing must operate to the detriment of the contact surfaces.

The third and great type of ball bearing is the so-called annular one intended for radial loads. It consists of three elements—two races and the balls. The new annular bearings require no adjustment or fitting, and the rolling action of the balls takes place without interference of friction. A wonderful advantage of this bearing is that as high as 96 per cent of the space between the races can be filled with balls, the balls being introduced through filling lots whose size is a little less than the diameter of the balls to be introduced, so that the balls are forced between the two races under pressure and by virtue of the elasticity of the material. In the annular bearing but 30 per cent of the balls are under load at one time, and it is possible for equal axle sizes and speeds to use different dimensions and loading according to the size of the balls. Table 8 gives suitable loads for equal shaft diameter, and revolutions for various sizes, and numbers of balls.

TABLE 8.

Shaft Diam. inches	Allowable load on Bearing, lbs.	R. P. M.	No. of Balls	Diam. of Balls, Inches
3.14	1,000	500	20	$\frac{1}{2}$
3.14	1,300	500	21	$\frac{9}{16}$
3.14	2,500	500	12	1
3.14	3,000	500	14	$1\frac{1}{16}$
3.14	4,500	500	11	$1\frac{7}{16}$

Annular ball bearings are also made with two rows of balls, and in the majority of them each ball is in a separate cage. Experiments have proven that, where the balls contact with one another, after a few years the friction results in grooves being worn in them. In Fig. 40 is shown the form of separator used in the F. & S. bearings. If in the application of this bearing it is

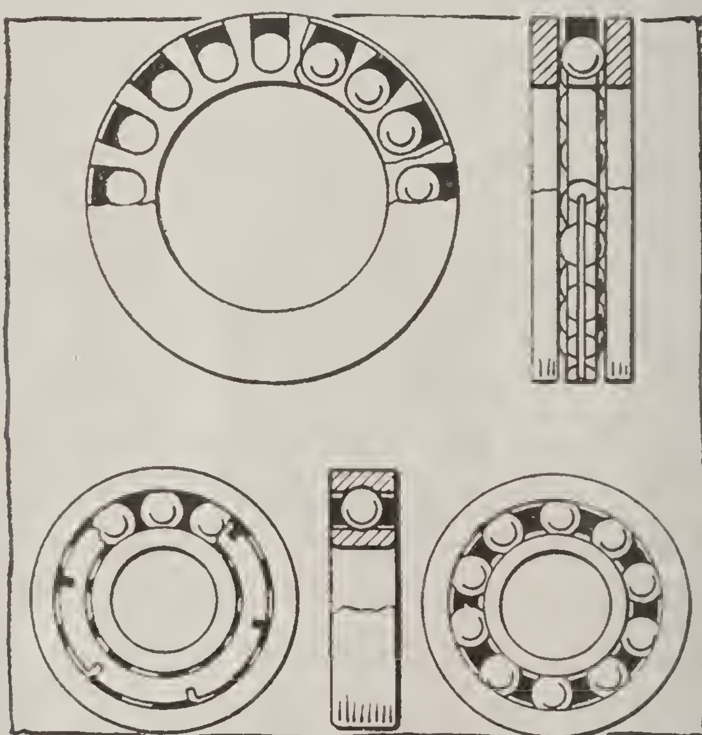


Fig. 40
F & S Bearing Separator

necessary to sustain heavy axle loads, it is absolutely necessary to add an independent thrust bearing, or to employ a combination bearing which takes the place of bolt thrust and radial loads.

Ball Bearings—Two in One. Figs. 41, 42, and 43 illustrate a ball bearing manufactured at Bristol, Conn., which, owing to its dual ability

as expressed by its name ("two in one") is especially adapted to automobile service. Its makers claim that it is able to withstand radial or thrust loads, or any combination of the two, with the use of but a single bearing with its attendant simplicity of mounting. In order to bring about this result, two rows of balls are employed in staggered relation to one another, and the ball races are so arranged that the line

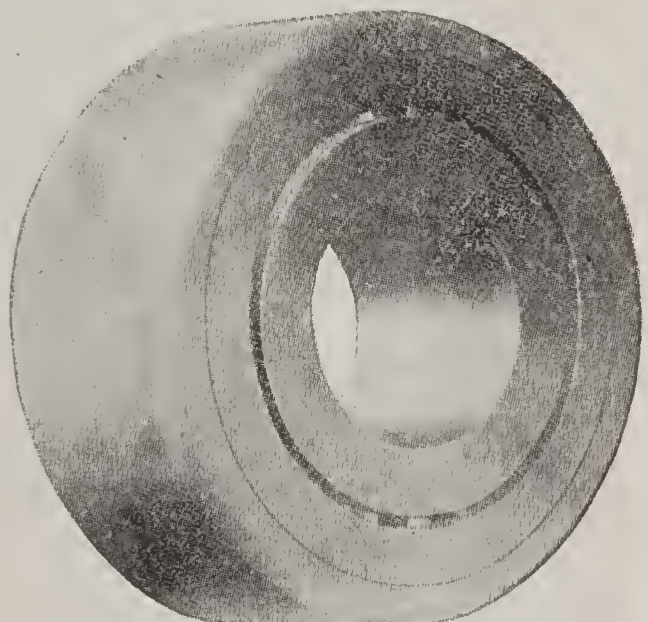


Fig. 41
Assembled Bearing Complete

of pressure is either at an angle of 45 degrees or 60 degrees with the horizontal, when the axis of rotation of the bearing is in a horizontal plane.

Figure 41 shows the permanent assembly of the bearing, sufficient metal being provided in the shell to permit of drawing the latter tightly over the cups.

Figure 42 shows the various parts of this bearing, and Fig. 43 is a semi-sectional view showing the order of their assembly, from the shaft outward, as follows; the cone, the separator, the two cups and the shell. It will be noticed that the line of pressure of the cone, cups,

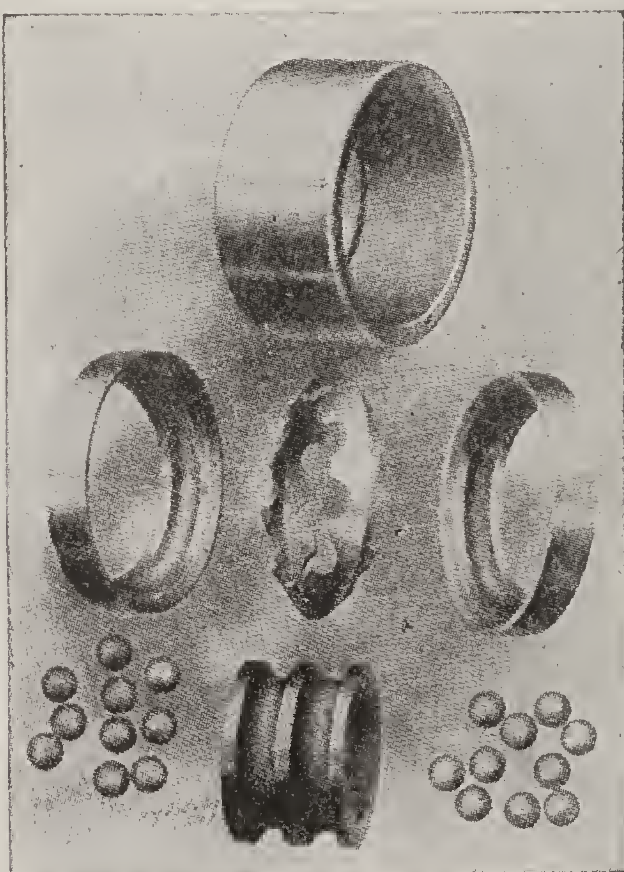


Fig. 42

and balls is at an angle of 45 degrees with the horizontal, and this feature applies equally to both rows of balls, thus adapting the bearing to withstand a load from any angle. Two semicircular races are turned in the cone to receive the balls, while the sheet metal separator is so stamped that the ball retaining notches are

staggered with reference to each other. These openings are made slightly larger than the ball diameter, so that the contact between the ball and separator is said to be a point contact at one end of the axis of rotation, while the weight by separator is carried on the balls at the top of the bearing. By maintaining the relative positions of the balls at all times, cross friction

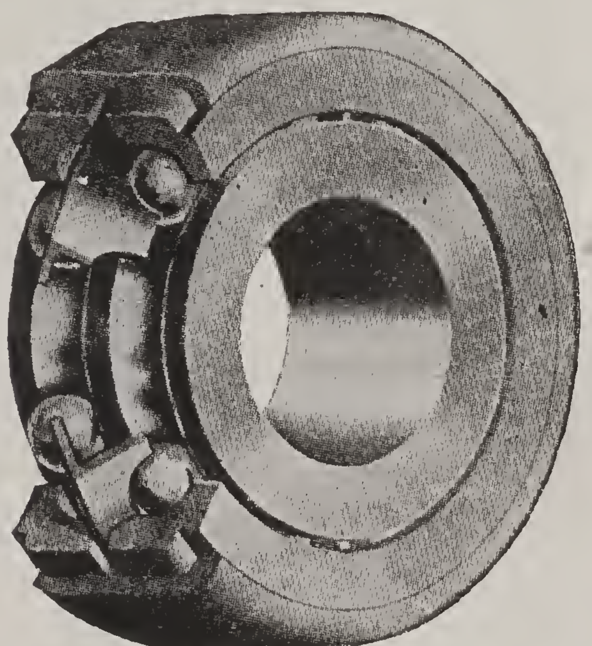


Fig. 43
Sectional View of Bearing

it is claimed is entirely eliminated, while the friction introduced by the use of the separator is practically negligible.

Ball Bearings—Lubrication of. Ball bearings must be so housed in as to retain lubricant and exclude dust, grit, etc. An impression that ball bearings will operate without lubricant is quite general. It is barely possible that absolutely true spheres might roll on absolutely

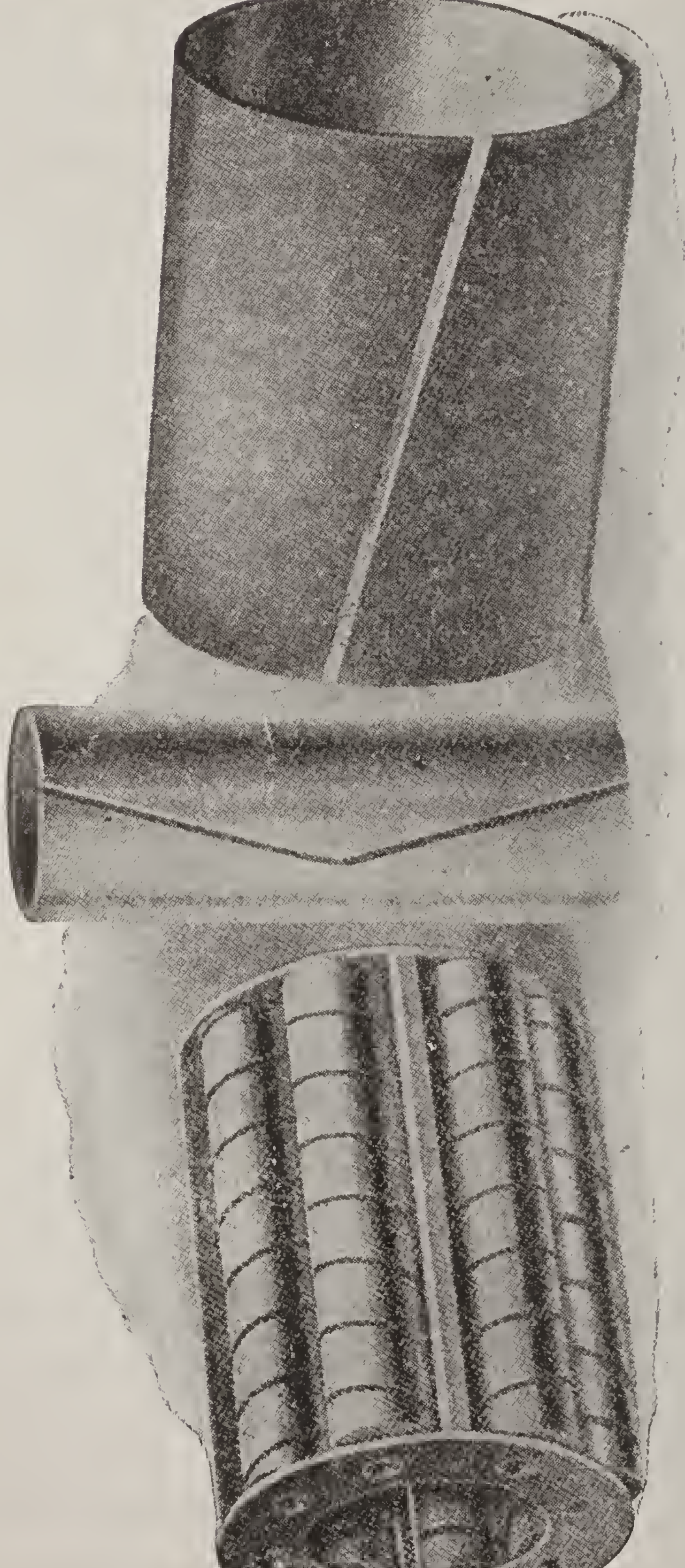


Fig. 43a
Hyatt Self-Oiling Self-Contained Roller Bearing

true surfaces if both were made of materials that were absolutely inelastic, and therefore would remain true under load. But since such absolute perfection of the shape is not to be had, some means must be taken to provide and retain lubricant.

Rust and acid must be kept out of ball bearings. Experience and most carefully conducted tests have proven that long life under load can be realized from ball bearings only when the surfaces are not only true, but are also highly polished and smooth. Roughness will be broken down and leave still greater roughness. Rust and acid will destroy originally true and smooth surfaces. Since not a few lubricants contain free acids, care in their choice must be exercised. Plentiful lubrication and a properly closed mounting are safeguards against rust.

Ball and Socket Joints. To produce a flexible joint capable of operation within certain limitations in any direction, the ball and socket form of joint is generally used on the ends of the rod which connects the arm of the steering mechanism with the steering lever attached to the hub of one of the steering pivots of the front axle.

Batteries—Dry. A dry battery of the usual type consists of a zinc cell which forms the negative element of the battery. The electrolyte is generally a jelly-like compound containing sal-ammoniac, chloride of zinc, etc. The carbon or positive element is enclosed in a sack

or bag containing dioxide of manganese and crushed coke, which are the depolarizing agents of the battery.

Dry batteries which have become exhausted may in most cases be recuperated in the following manner: First disconnect the cells from each other and remove their pasteboard covers, then drill a hole in the sealing compound on top of the cell, about one-quarter of an inch in diameter and at least 2 inches in depth so as to insure getting below the sealing compound. Take 1 ounce of bisulphate of mercury and put in a porcelain or earthenware vessel (on no account use a metal vessel) and pour over it one-half pint of boiling water—when cold, draw off the clear solution, being careful not to disturb the yellow precipitate left at the bottom of the vessel, which is useless and should be thrown away at once, as it is a rank poison. Dissolve 4 ounces of sal-ammoniac in 1 pint of hot water and when cold mix with the first solution and the recuperative agent is then ready for use. Take a small glass funnel, or a tin one that is thoroughly painted or enameled, and introduce about a tablespoonful of the liquid into each cell through the hole already drilled for this purpose. The liquid must be introduced into the cells very slowly, as it will take a long time to absorb, and the cells should be allowed to stand at least 12 hours after filling before being ready for use.

PRIMARY BATTERIES. When there is no in-

candescent light circuit at hand or the electric current is of the alternating type, primary batteries of some form or other are very useful to charge small storage batteries which are used for ignition purposes.

The voltage of a set of primary batteries to be used for charging a small storage battery, should exceed the voltage of the storage battery by at least 30 per cent.

Primary batteries of the open-circuit type, such as sal-ammoniac cells, are useless for charging purposes, only batteries of the closed-circuit, or constant current type are suitable.

A very simple and inexpensive form of closed circuit battery for charging purposes is the single liquid type, which uses zinc and carbon electrodes in a 20 per cent solution of sulphuric acid and water, with nitrate of soda as the depolarizing agent.

For a 4 volt storage battery four such cells are required, while for a 6 volt storage battery six cells will be necessary for a proper charge.

This form of primary battery has a voltage of 1¾ volts per cell.

The articles necessary for a complete charging outfit are as follows: One small pocket ammeter reading up to 5 amperes, one two-point switch, one resistance coil or rheostat (home made), one set of closed-circuit type of primary batteries, and about 25 feet of No. 16 B. & S. Gauge, Okonite or Kerite stranded copper wire for the connections.

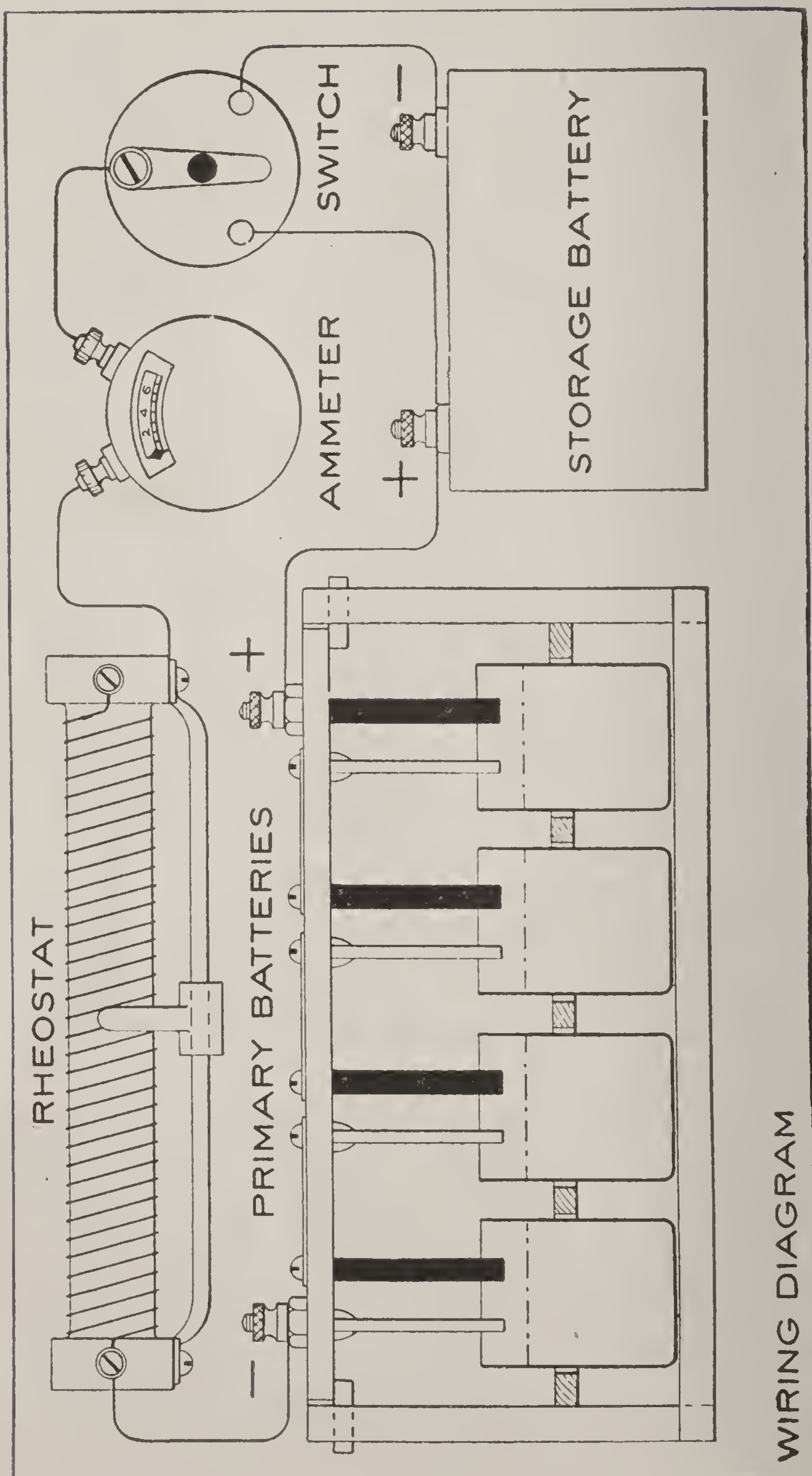

SWITCH
AMMETER
STORAGE BATTERY
RHEOSTAT
PRIMARY BATTERIES
WIRING DIAGRAM

Fig. 44

The method of connecting the primary batteries, resistance coil (rheostat), ammeter and switch is plainly shown in Fig. 44. The positive pole of the primary battery should always be connected with the positive pole of the storage battery, the carbon element is always the positive electrode in both dry, and primary forms of batteries. If the polarity of the terminals of the storage battery are not indicated on the case by the + and — signs, which represent positive and negative respectively, their polarity may be readily ascertained by means of a piece of moistened litmus paper (paper soaked in a solution of iodide of starch). Place the piece of moistened litmus paper on a board or other non-conducting material and bring the wires from the storage battery terminals into contact with opposite ends of the paper for a few seconds only—one end of the paper will turn red, this will be next to the wire connected with the negative pole of the storage battery.

The resistance coil or rheostat may be made very simply as follows: Take a piece of hardwood 3 inches square and 15 inches long and turn down about 13½ inches of its length to a diameter of 2½ inches in the manner shown. Upon this turned part cut with a round-nose tool a groove or thread one-sixteenth of an inch deep, with 8 threads to the inch. In this groove wind about 50 feet of No. 18 B. W. Gauge bare soft iron wire and connect with a bar and sliding contact as shown in the drawing.

To charge the storage battery, move the sliding-contact to the right until all the resistance is in use, then move the switch-finger to the point on the left and adjust the sliding-contact by moving it to the left until the ammeter shows 3 amperes. Moving the switch-finger to the right will put the battery in the circuit for charging, and the sliding-contact should be again adjusted until the ammeter shows 3 amperes. The sliding-contact should be adjusted from time to time to keep the charging current at 3 amperes.

If the storage battery be of 12 ampere-hour capacity it will take 4 hours to properly charge it, if of 18 ampere-hour capacity, 6 hours. The ampere-hour capacity of the battery divided by the amperes of the charging current gives the number of hours required to fully charge the battery when exhausted.

After the storage battery is fully charged the electrodes should be lifted out of the solution as shown in the drawing, by means of the cover to which they are shown attached, until the battery is again required for use.

Selecting a Battery for Ignition. Practically every gas engine works most satisfactorily with a 6-volt battery. However, in some instances a lower or higher voltage is frequently required, owing to the variation in the compression, and the style of coil and ignition equipment used.

If dry cells are used, figure one dry cell for

each volt of storage battery. For instance: 3 to 4 dry cells will require 4-volt storage; 5 to 6 dry cells will require 6-volt storage; 7 to 8 dry cells will require 8-volt storage.

Battery Connections. There are a considerable number of methods which may be used for connecting the ignition devices in the cylinder to the source of current, each of which involves different forms of apparatus and different methods of connections, especially in the jump-

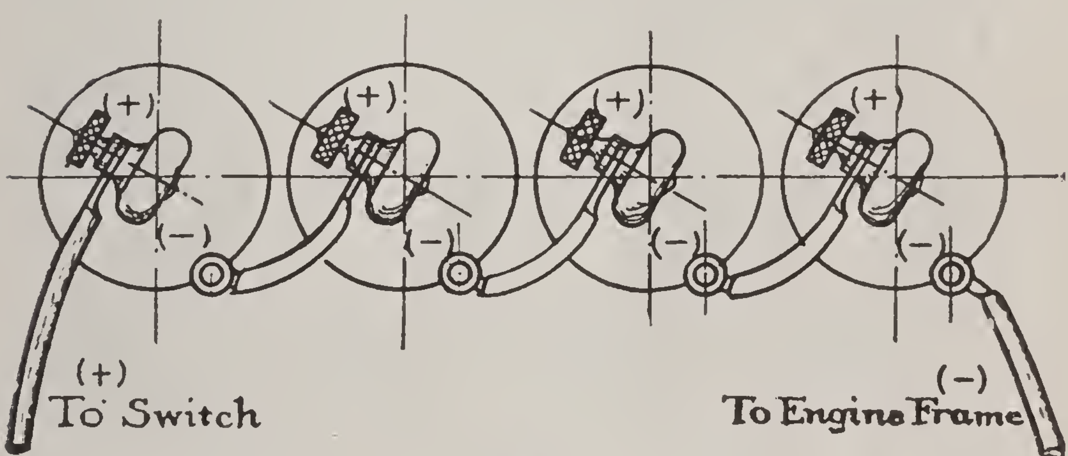


Fig. 45
The Ordinary Battery Connection, in Series

spark systems. The make-and-break systems, owing to their comparative simplicity, do not differ very much in the method of connection.

Two methods are usually employed, viz.: series, and multiple, or parallel. To connect dry batteries in series, the terminals are joined alternately, that is, the zinc of the first is connected to the carbon of the second, the zinc of the second to the carbon of the third, etc.

When so joined, the positive element is left free at one end, and forms the positive terminal

of the group, which is then considered as a unit. The other free end (the negative) forms the negative terminal of the unit, see Fig. 45, which shows four cells connected in series.

Figure 46 shows four cells connected in parallel which means that all of the positive terminals are connected to one common wire, and all negatives are connected to another wire.

This mode of wiring up the cells gives a smaller output for the group. Thus if the individual batteries have an internal resistance

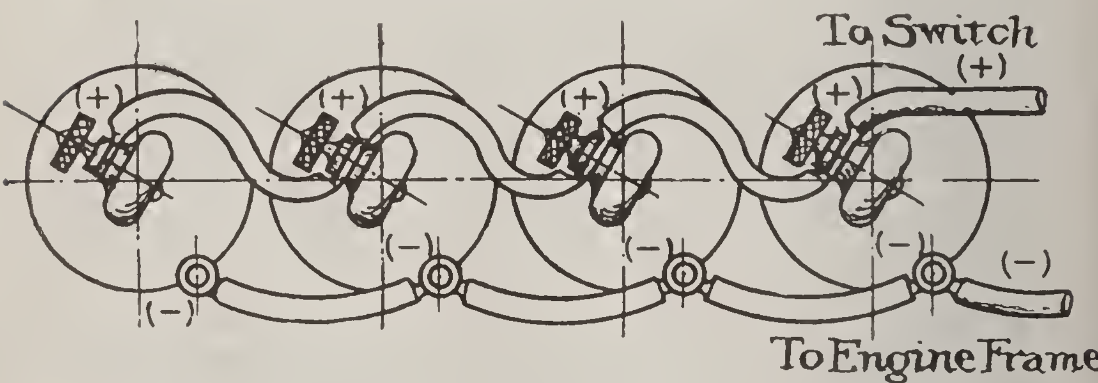


Fig. 46
Parallel Connections are Not as Frequently Used

which is low in comparison with the external resistance, the total output will be but slightly more than that of a single cell. If, on the other hand, the internal resistance is high relative to the external, the current will be roughly proportional to the number of cells.

Where the cells are divided into sets or groups of a small number (four is usual), and more than one of these sets are used at a time, there are again two methods of joining them: These two are the same as before, viz., series and multiple.

The former is very seldom used, if ever, but the other is rather common. When two or more sets of batteries, themselves connected in series are, as sets, joined in multiple the whole is spoken of as connected in series-multiple.

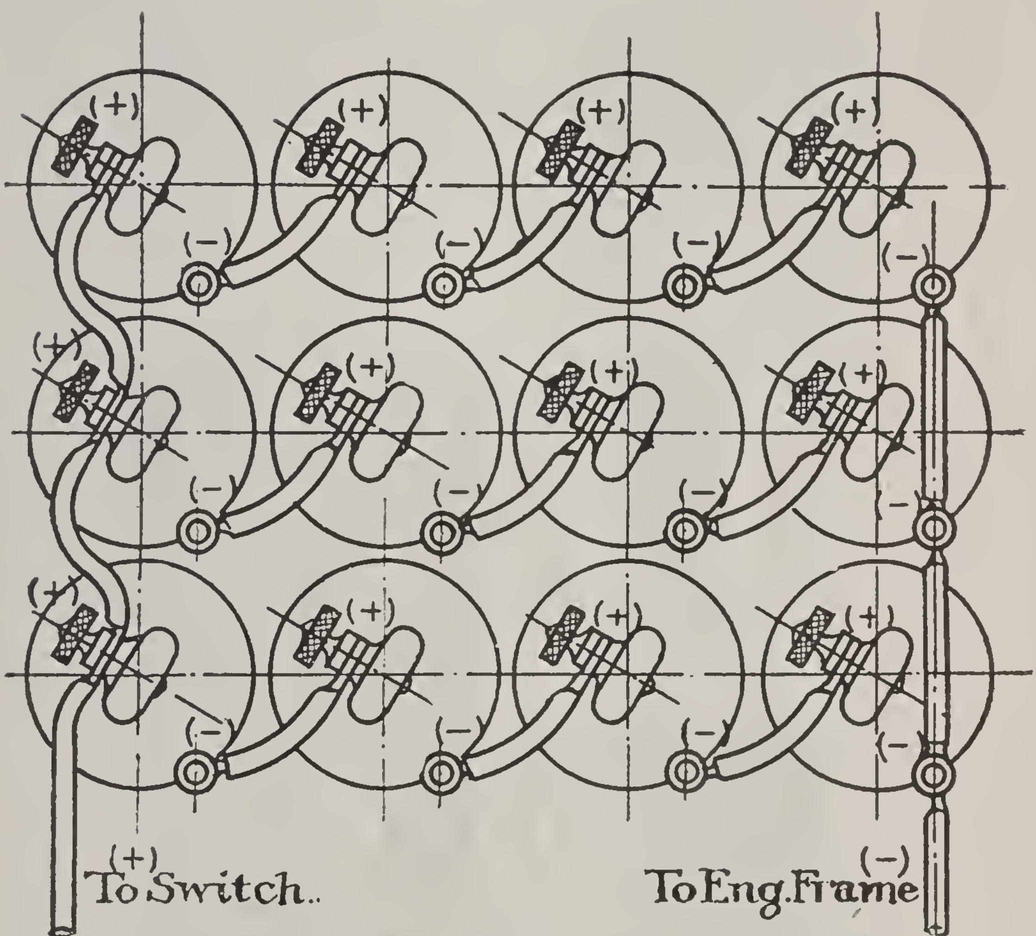


Fig. 47

Batteries—Storage. A storage battery as used in ignition service, is usually of the lead, lead type, in which the electrolyte is sulphuric acid and water of a density about 1.2— specific gravity. The plates are of two classes—positives and negatives—there being one more negative than positive in each nesting in a cell. The elements of a cell of storage battery are

given in Fig. 48, and consist of the following: Positive plates A, of which there is one fewer than of negatives; negative plates B, of which there is always one more than positives; sepa-

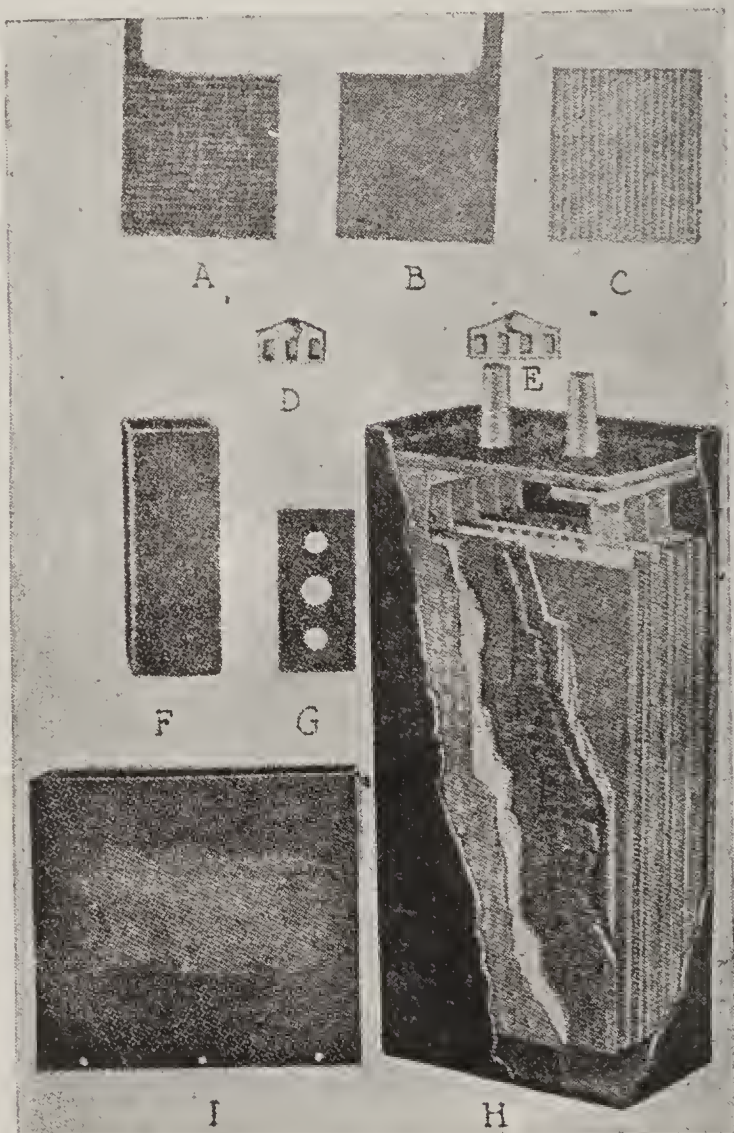


Fig. 48
Elements of Assembled Battery

rators C, which may be of wood, rubber, or other suitable material, and if of wood must be treated; positive strap D, the function of which is to connect all the positive plates, across the

top, into electrical relation; negative strap E, the function of which is to connect all the negative plates, at the top, in electrical relation; battery jar F, made of rubber composition, light, strong and acid proof; cover for the jar G, with holes for the terminals of the elements, and a vent; assembled cell of battery H, showing the elements in place, separated, with cover on; ready for connections; and a battery box I, of oak, usually contrived to hold three cells of battery, sometimes two.

The positive and negative plates, called elements, consist essentially of a grid in each case, made of lead-alloy, in which antimony is used to engender stiffness. The grids are in divers forms, depending upon the views of several makers, the idea being to afford space for the active material, and to lock the same in, so that it will not drift out, as it is prone to do, under the action of the charging, and discharging current. Surface is the great requisite, and it is the aim to afford the maximum area of the finished plates, per pound of active material used; limiting the weight of the supporting grid, in so far as it is possible to do so.

The voltage of a battery of this type is usually 2.2 volts when the circuit is closed, but it drops to 2 volts within the first hour of using, which pressure it usually maintains during the next 5 hours, after which the voltage declines at a rapid rate.

Adding Water to Cells. In service water

will have to be added to the cells to compensate for evaporation, and for the loss that takes place during charge, brought about by the entraining of water with the bubbles of gas that shoot off and out of the jars, if they are open, that is to say, if the covers are removed before and left off during charging, which is not usually the case. The result in any event is in favor of increasing strength of the electrolyte, and water will have to be added from time to time in order that the plates may not be exposed to the atmosphere above the line of active material; which is a point that must be cared for if the battery is to last for a long time. The water so added should be pure—distilled—and the right quantity to add, will be determined by means of a hydrometer placed in each cell between the separators if there is sufficient room, or the electrolyte may be withdrawn through the utility of a gun made of hard rubber with a long slender neck. The test should be made when the battery is charged and every cell should be examined rather than to test one cell and conclude that all are in an average condition.

Storage Batteries—Care of. Among the troubles that ultimately attend batteries in service the following are the most conspicuous:

Hardening of negative elements; local action; buckling of plates; shedding of active material; sulphation; reversal of negative elements; disintegration of grids; protruding active material; deformation of separators; broken jars; in-

cipient short circuits; defective electrical contact; loss of capacity; loss of voltage; corrosion of plates, and needle formations.

Hardening of the negative elements will follow if they are exposed to air, as when the electrolyte is allowed to fall below the level of the plates, from any process that will produce over-oxidization if the temperature is allowed to increase much above 90 degrees Fahrenheit. When the negative elements are hard, to reduce them back to the normal condition, assuming the process is not too far gone: Remove the elements from the jar, place the negatives in a cell, with dummy positives, and charge until the negatives are corrected, taking care not to charge at a too high rate. High temperature and excess boiling should be avoided. If the negatives are charged in their own cell with the regular positives the positives will be damaged by the excess charging that will be necessary to reduce the negatives. When the negatives are sufficiently charged to correct the evil they may be returned to their own cell, and when connected up with the positives the cell will be ready to go into service again, if in the meantime the positives are given such attention as their condition would seem to indicate. Local action, following impurities in the electrolyte, will only be prevented as much as it is possible to do so when the electrolyte is removed and pure electrolyte substituted in its stead. This should be done when the cells are fully charged

The electrolyte will hold most of the impurities when the battery is in the fully charged state.

Buckling of plates, when batteries are defective in design, rather than in cells of normal characteristics, is a trouble that will follow in any cell if the discharge is allowed to extend below 1.8 volt as indicated by the cadmium test, rather than by the usual potential difference reading across the two sets of elements in the cell. If the rate of discharge is excessive, a condition that is not likely in ignition work, buckling will follow also. Short-circuiting the elements to see if the battery is alive will tend to buckle the plates, due to the heavy discharge, and the uneven rate of discharge over the surfaces of the elements. In defective construction, if the active material is not of the same porosity, thickness, and in the same condition all over the surfaces of the plates, buckling will follow.

Shedding of the active material, to a slight extent, is a normal condition of batteries; and to prevent trouble due to incipient short circuits, such shedding is cared for by having a space in the bottom of cells to hold such shedded material. When elements are of inferior design and improperly constructed the active material will shed at a rapid rate, and the user of the battery can do nothing more than demand a new battery to replace the defective one. If charging is done at a too rapid rate the active material will be loosened by the rapidly escaping gas, and even on discharge, if the

rate is high, the shedding of active material is likely to follow.

Sulphation, which is a normal expectation during discharge of a battery, introduces serious complications under certain conditions as when the active material is not in intimate contact with the grids thus allowing the electrolyte to get between the grids and the active material, with the result that sulphate, which is a high resistance material, isolates the grids and reduces the efficiency of the cell in two ways: first, by increasing the ohmic losses, and, second, by lowering the chemical activity. Excess sulphate is prone to form when the electrolyte is out of balance, and one of the best ways to abort this action is to keep the electrolyte within the prescribed limits of strength. If sulphate is allowed to form until white crystals show over the surfaces of the plates, it is highly improbable that the cells will ever be of sufficient service to warrant continuing them in service. The only way to afford relief lies in reducing the growth of sulphate by continuous charging the sick elements in a cell with dummies until the sulphate is reduced. A slow rate for a long time may bring about a reform.

Negative elements to be reversed must be below capacity, or the cells must be discharged to zero and then reversed. In charging it is always necessary to make sure that the connections are made in such a way that current will flow into the battery, rather than out of it. Volt-

meters in which permanent magnets are used will serve as polarity indicators, and with them it is possible to proceed with safety. If a battery is connected up in reverse when it is put on charge, instead of being charged it will be discharged, and then charge in reverse. While it is discharging it will deliver current to the line.

Disintegration of grids will follow if the impurities are allowed to enter the electrolyte, as iron, etc. Continued charging will also have the effect of reducing the grids to form salts of lead.

Protruding active material, due to expansion and displacement of the same, indicates a lack of binding relation between the grids and the active materials. There is no remedy. Deformation of separators, when they are made of rubber compound, follows when the cells are allowed to heat beyond a certain point. This trouble will be aborted if the cells are charged at a normal rate, and if the temperature is not allowed to increase beyond about 90 degrees Fahrenheit. When wood separators are used they will slowly rot and in time it will be necessary to replace them.

Broken jars will allow the electrolyte to leak out, and frequently the fracture is but a minute crack, so that it is well to be on the lookout for just this kind of trouble. If the jars are properly nested and motion between them is prevented they will as a rule serve without breaking.

Incipient short circuits are likely to go unnoticed. They are generally due to detached particles of active material that lodge between the plates, especially in vehicle and ignition types, owing to the short distance separating the plates, and the use of separators, such as perforated rubber in the absence of wood, which have the virtue of being porous but too close to allow the active material to bridge across the space between the plates.

Defective electrical contact is due to corroding of joints that are not made by burning.

Loss of capacity may be traced to such causes as: If the electrolyte is out of balance or below the level of the top of the plate; loss of active material from the grids; sulphate formed on the surfaces of the grids, isolating the active material; lack of porosity of the active material; impurities and sulphate clogging up the pores of the active material; low temperature; high temperature; persistent sulphation, and intercell leakage due to electrolyte spilled over the surfaces, especially if jars are in actual contact with each other.

Loss of voltage, as distinguished from loss of capacity, follows in a battery when one or more of the cells are dead or below voltage. If one or more of the cells are reversed they will set up a counter-electro-motive force, and the over-all reading of the battery will be reduced accordingly. The remedy is obvious. All the cells

should read the same way, and all should have the same difference of potential, respectively.

In view of the sulphated condition that attends all batteries that are discharged at a low rate for a long time, as is the case in ignition work, it is necessary to charge at a low rate for a long time in order to reduce the sulphate, which is in persistent form and very difficult to reduce. It will not be enough to correct the strength of the electrolyte once during the charging process for the reason that it will be difficult, if not impossible, to ascertain the condition of the same with any degree of accuracy, and the necessity for noting strength two or three times in the act of charging is apparent. When the battery is fully charged, which may take even sixty hours of continuous charging at a low rate, the electrolyte in every cell should stand at full strength, considering a state of full charge, and the color as well as other indications of a full charge should be fully noted. Boiling at a slow rate should be tolerated for several hours, but the temperature should be held at about 90 degrees Fahrenheit during the entire time. If a battery is charged at frequent intervals it will last longer in service, give less trouble in charging and will be more reliable in service. It is well to begin charging directly a battery is taken out of service as any delay after that time will result in a marked deterioration of the cells.

When a car is put out of commission, even

for a few weeks, the battery should be given a light discharge, and a subsequent charge as often as once a week, until it is again brought back into use.

STORAGE BATTERIES — CHARGING. Positive plates in the charged state are of a velvety brown or chocolate color; negative plates have the color of sponge lead, which is very nearly light gray. When a battery is approaching a condition of full charge the color tones up quite noticeably, and it is possible to mistake a condition of full charge, if color alone is taken as the evidence; the exterior will have the appearance of full charge, since the active material, on the exterior surface, will reach its charged form first; if the thickness of active material on the grids is very thick, as it is likely to be in low discharge rate work. charging by color, as evidence of a state of full charge, will be to limited advantage. Details regarding correct methods of charging storage batteries are given under the head of Primary Batteries.

STORAGE BATTERIES—TESTING. Tests for impurities in the electrolyte may be made as follows. For iron;

Neutralize a quantity of the electrolyte to be investigated, after diluting the same, by the addition of an equal amount of pure distilled water, using strong ammonia water for the purpose. To the solution, so neutralized, add one-thirtieth of the amount of the same of hydrogen peroxide, thus reducing any iron present

to the ferric state. If a sample of this solution is rendered alkaline by the addition of a sufficient quantity of ammonia water, then, if iron is present, enough to amount to anything of great moment, from the battery point of view, a brownish red precipitate will form. A test for chlorine is as follows:

Make a solution of nitrate of silver in the proportion of 20 grams of the same, in 1,000 cubic centimeters of pure distilled water, and add a few drops of this solution to a small quantity of the electrolyte to be investigated; if chlorine is present the solution will turn white, owing to the formation of chloride of silver, which will precipitate out.

A test for nitrates is as follows: In a test tube, holding 25 cubic centimeters of electrolyte to be tested, add 10 grams of ferrous sulphate; to this carefully add 10 cubic centimeters of chemically-pure sulphuric acid by pouring the same slowly down the side of the tube; in the presence of nitric acid, a brown solution will form between the electrolyte to be tested, and the concentrated solution of sulphuric acid.

The presence of copper may be detected from the fact that when ammonia solution is added to electrolyte, a bluish-white precipitate will form. In testing for mercury, lime water, if it is added to electrolyte in which mercury is present will evolve a black precipitate. Testing for acetic acid is as follows: To a small quantity of the electrolyte to be tested, add enough am-

monia water to render the same neutral; ferric chloride added to this solution will cause the same to turn red in the presence of acetic acid and the solution will then bleach, provided hydrochloric acid is added, thus affording conclusive proof of the presence of the undesired acetic acid.

Bearings. The bearings of an automobile, although classed among the smaller parts of the machine, are nevertheless very important factors, and if not properly constructed, and cared for will cause much unnecessary friction. The essentials of a good bearing metal are; (a) that it shall possess high anti-frictional properties, and be able to withstand heavy pressures at high speeds, without heating; (b) it should be of sufficient hardness to prevent it from being squeezed out of place under heavy loads, or being cracked or broken under severe shocks, or blows; (c) it should be easily renewable when worn out. Ball bearings having been already described it is unnecessary to again allude to them, except to say that while they cause less rolling friction than do plain bearings, still they involve considerable loss of power, due to the fact that they roll in opposite directions, and consequently rub against each other, with the result that the balls soon wear out.

Hard and Soft Bearings. There are two general classes of solid bearings, those which contain a large per cent of copper and a small amount of the softer metals; which are known

as hard metals, as brass or bronze. Those which contain a large proportion of tin or lead and a small per cent of copper are known as soft metals—as babbitt-metal, anti-friction metal and white metal.

In some instances and under certain conditions it has been found that a good close-grained cast iron makes an excellent bearing metal. Being of a granular nature, it has the property of retaining the lubricant in place, even when highly polished and under great pressure, with

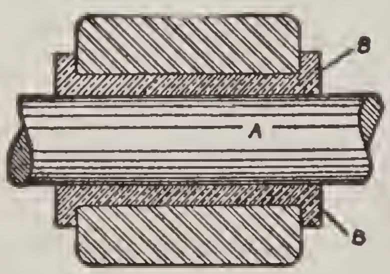


Fig. 49

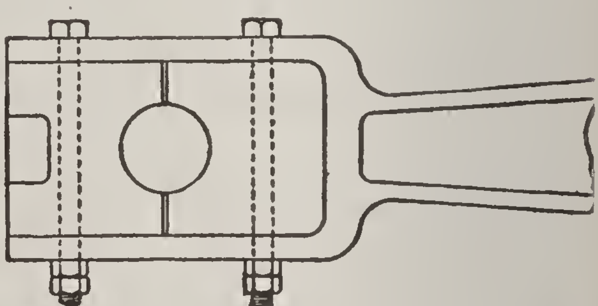


Fig. 50

Types of Plain Bearings

a low co-efficient of friction, but is too brittle to withstand severe shocks.

Plain Bearings. Plain solid bearings are used on many parts of an automobile, particularly in the engine and transmission bearings, although ball and roller bearings are taking their place in many constructions. The majority of the cars use brass, bronze or babbitt-metal on the main and crankshaft bearings, while ball and roller bearings are used on the transmission and wheel bearings. A typical plain bearing is shown in Fig. 49, in which A is the journal made of steel, while the bearing members shown at

B. B. are made of either brass, bronze, or babbitt metal. Figures 50 and 51 show different types of connecting rod bearings. For plain-bearings, the shafts of which are continuously running at a high rate of speed, such as motors and speed-change gears, the working pressure

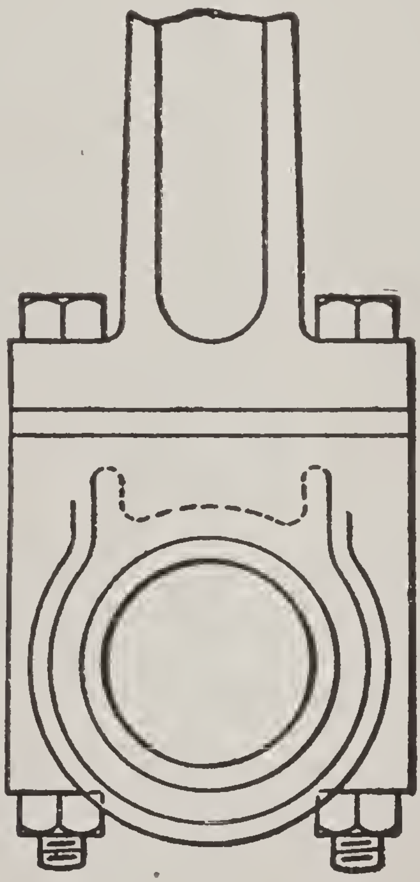


Fig. 51
Solid Connecting Rod Bearing

per square inch should not exceed 400 pounds. As the arc of contact or actual bearing surface of a journal bearing is assumed as one-third of the circumference of the journal itself, the pressure per square inch upon a bearing is therefore equal to the total load upon the bearing, divided

by the product of the diameter of the journal times the length of the bearing.

Let D be the diameter of the journal or shaft at its bearing, and L the length of the bearing, if W be the total load or pressure upon the bearing and P the pressure in pounds per square inch of bearing surface, then

$$P = \frac{W}{D \times L}$$

If the total load or pressure on the bearing be known and the diameter of the shaft given, then the proper length of the bearing will be

$$L = \frac{W}{D \times P}$$

If the length of the bearing be known and other conditions as before given, then the proper diameter of the journal will be

$$D = \frac{W}{P \times L}$$

When fitting a new bushing to a wheel the spindle should first be removed from the axle, placed in a lathe, and tested to see if it is true, and if not true a slight cut taken off to true it up. Next fit the bushing in the wheel, then the wheel on the spindle. If the spindle is slightly bent or twisted the wheel may run free when the car is jacked up, but hard under a load. If a bushing is first fitted to a spindle and then

driven into the wheel, it will probably be too tight when placed on the spindle.

The length of a plain-bearing should not be less than the following proportions:

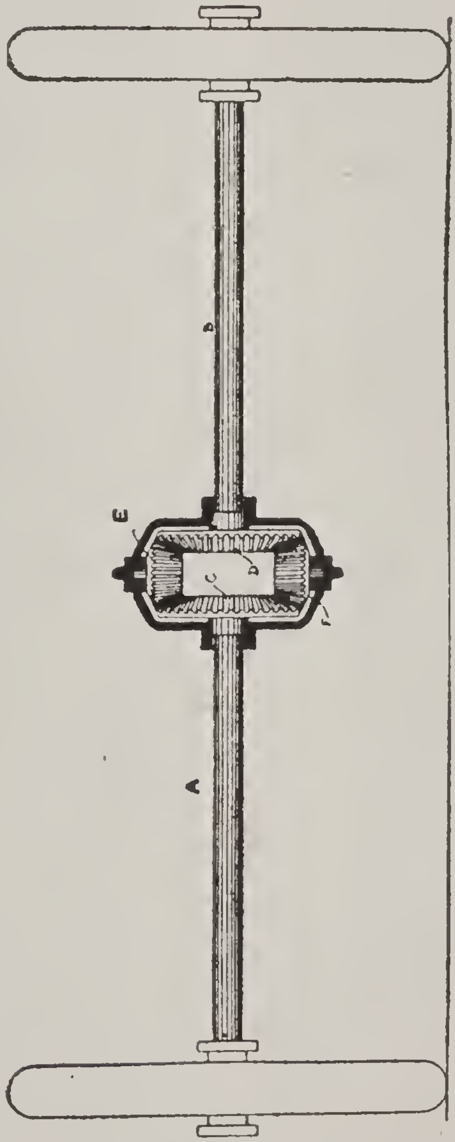


Fig. 52
Bevel Gear Differential

One and one-third diameters for crank-shaft wrist-pin bearings.

Two diameters for crank-shaft bearings.

Two and one-half diameters for speed-change gears.

Three diameters for live rear axles.

Four diameters for wheel hub bearings.

Bevel Gear Differential. Figure 52 shows a bevel gear differential in which A and B are the two halves of the rear axle, which is divided at its center. One of the driving wheels is carried on A, and the other one on B, while the inner ends of the two half axles are each fitted with bevel gear wheels C and D. Meshing with these two bevel gears are two, three or four bevel gears, two of which are shown at E and F. These pinions are supported on radial studs which project inwardly from the casing. Upon this casing are sprocket or bevel gear teeth which are driven from the engine. The teeth of each pinion, E and F are at all times in mesh with the teeth of both the bevel gears C and D on the axle. When the car is in operation, the chain or bevel drive revolves the case containing the pinions, and the power is transmitted through the teeth of the pinions E and F to the teeth of the gears C and D and thence to the axle and wheels. So long as the vehicle travels in a straight line, the pinions act as stationary driving members, and have no occasion to revolve, as the two halves of the axle and their gears are moving at equal speeds. They merely revolve with the frame. The same teeth of the bevel pinions and gears are in contact so long as a straight path is traversed. When, however, the car is steered in a curve and different velocities are required in the drivers and the bevel gears with which they are connected, the pin-

ions no longer act as fixed driving members, but each turns upon its stud and allows the necessary relative motion between the two bevel gears, and at the same time they continually transmit power to the two ends of the axle because they are always in mesh with each other. This compensating action may continue indefinitely through any amount of variation between the driving wheel rotation, because one

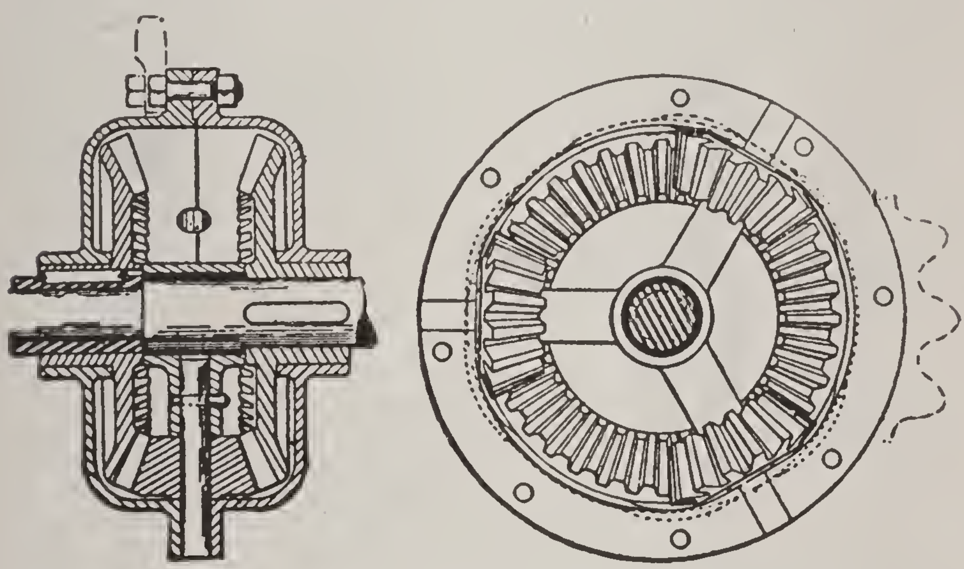


Fig. 53
Bevel Gear Differential Connected to Sprocket

tooth of the pinions comes into play as fast as the preceding one disengages with the bevel wheels on the shaft. Fig. 53 presents a larger view of the bevel gear differential, the two gears on the rear axle being shown as secured to the shaft, and to a sleeve on the shaft. The differential employed here has three bevel pinions turning on radial studs, which are secured to the arms of a spider at their inner end. A differential bevel gear, although most exten-

sively used, is open to the objection that the bevel gears impose an end thrust upon the two halves of the mainshaft on rear axle. This has led to the design of differentials in which only spur gears are used.

Binding-Posts. Two forms of terminals or binding-posts are shown in Figure 54. The one shown at the left in the drawing is more suitable for induction coil and dash-board connec-

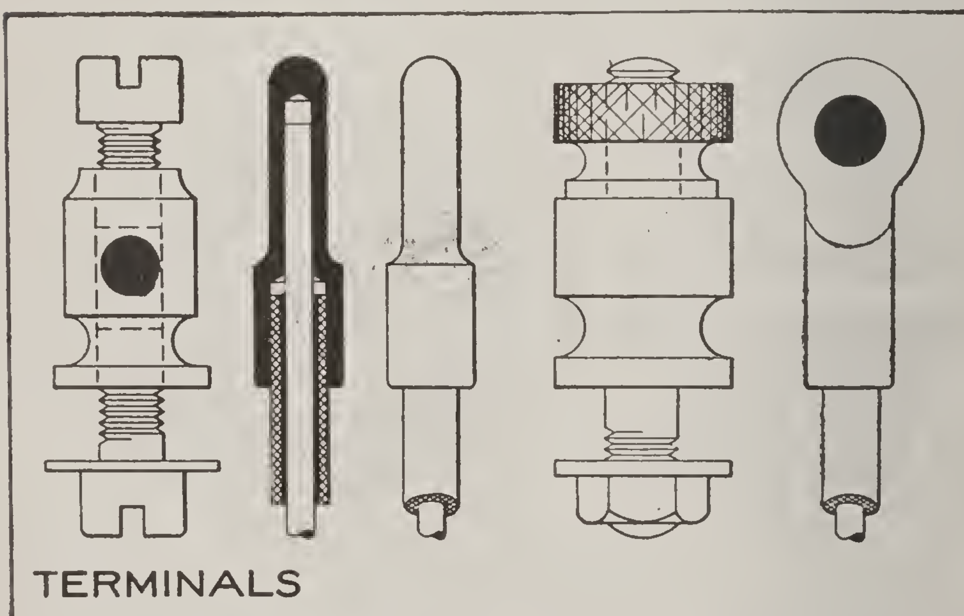


Fig. 54

tions. A tip or connector is also shown for use with this terminal, which gives a far better electrical contact, than by the ordinary method of inserting the bared end of the insulated wire in the terminal itself. The bared end of the wire is sweated into the hole in the smaller portion of the connector as shown, the sheath or covering of the wire going into the hole in the larger end of the terminal. These tips are usually

made of brass. The right-hand view shows a terminal or binding-post for storage battery use, which is heavier and larger than the one shown in the left-hand view. The connector for use with this terminal is also shown. The wire is attached in the same manner as for the other connector.

With storage battery terminals, corrosion is inevitable unless the lead and brass parts are, when new, taken apart, and carefully painted with raw linseed oil or vaseline, and screwed up again. The entire binding-post may be drenched in linseed oil, it will not only prevent corrosion, but, strangely enough, improve the electrical contact between the wires and the faces of the terminals.

Bodies. In the construction of automobile bodies the sills are made strong, and the superwork is rendered independent of the actual structural strains. Wood is generally used in the framing, although it is sometimes replaced by cast aluminum.

When wood is used for framing, sheet aluminum, steel and thin layers of wood are employed. The aluminum is laid on a form and beaten to the shape required for the panel. The steel sheets are die formed, while the wood is made flexible in order that it may be bent to its proper shape when fastened to the body. In order to have the car of light weight, all body builders use the lightest materials possible in

the construction of that portion which lies above the chassis.

When aluminum is used in the panels and for facings, care must be exercised to prevent water from creeping in between the metal and the framing, because water causes an electrolytic action on the aluminum plates. To prevent the oxidation of sheet steel, the plates are either coated with aluminum or zinc, or they are given a priming coat of paint on the inside.

As a general thing, putty is not used in the construction of bodies, as there are few joints which require it. In the very best body painting twenty coats are used before the paint assumes its proper finish. The first coat, or priming coat, generally consists of pure white lead mixed in oil. After that the second priming coat is given to it, and from then on the number of coats of rough paint will depend upon the nature of the surface and the degree of finish. For a very fine finish, the last coats consist of varnish, but when wagon finish is desired, the last coats consist of paint.

Finishers must take into account the fact that all cars are more or less abused in service, and it is to be expected that the magnificently equipped limousine will have a somewhat finer finish than the hard used touring car.

Classification of Bodies. Besides being classified according to the type of gasoline engine, methods of transmission, number of cylinders, etc., automobiles are also classified ac-

cording to the type of body which is mounted on the chassis. While there are a considerable number of names which are given to the same types of pleasure automobiles, they may be generally classified as runabouts, roadsters, tourabouts, touring cars, town cars or taxicabs, landaulets, limousines and semi-limousines. Electric automobiles are generally divided into coupes, brougham, stanhopes, runabouts, phaetons, etc. Steam cars follow the same general classification as gasoline machines. Commercial vehicles may be classified as taxicabs, delivery wagons, trucks, busses, wagonettes, ambulances, patrol wagons and other forms for fire service.

Commercial Vehicles. In the commercial vehicle field steam, electric and gasoline machines are used. Electric vehicles are used for certain purposes, from heavy trucks to light delivery wagons, usually only for short distances; steam is used widely for all purposes, principally for heavy trucks, while the gasoline commmercial is used for trucks, business wagons and quick deliveries.

The commercial vehicle may be classed as follows: Taxicabs, general delivery, light trucks, heavy trucks, coal wagons, sight-seeing cars, busses, ambulances and particular other types for special purposes.

Since, for general purposes, the speed of commercial vehicles is small, they are not necessarily equipped with high power, as a heavy

car, which would travel at a high speed, would be apt to be dangerous. The speeds obtainable range on an average between twenty miles per hour for delivery wagons, to five miles per hour for heavy trucks.

LIMOUSINES. With the increased use of the automobile for winter use has come the limousine with all its luxurious fittings. They are now heated in winter, are furnished with the finest and most expensive upholstery, contain speaking tubes, electric light, bouquet holders: in fact, nothing seems to be too fine for what is strictly the rich man's car. As they are extremely heavy, they are generally equipped with tires of large sizes, and as a general thing they are made with a shorter wheel base than standard touring cars.

ROADSTERS AND RUNABOUTS. Runabouts as a class have a comparatively low-wheel base, limited to about ninety inches, whereas roadsters are essentially long wheel-base cars, between 100 and 120 inches, because the speed at which they run makes this necessary. Runabouts are designed for starting and stopping quickly, whereas roadsters, as their name implies, are intended to be used on all road conditions.

TAXICABS. The general considerations involved in the design of this type of vehicle are somewhat similar to those governing the design of a low-powered touring or town car, but a number of minor requirements, not usually ac-

corded much attention in touring car design, attain considerable importance in the motor cab. Economy of operation is perhaps the most salient of these, while low speed and short turning radius are next in importance in their effect on design.

A motor of from twelve to fifteen horsepower, at a speed of 1,000 to 1,200 revolutions per minute, is ample for cab service; although some taxicabs are built with only eight or ten horsepower. Both the two-cycle and four-cycle types of motors are extensively used.

Touring Cars. These types of cars may be divided into two classes, light touring cars and standard touring cars. Light touring cars generally have a wheel base of about 110 inches, and seat five persons comfortably. Motors are generally of the four-cylinder type, rated at from twenty to thirty horsepower. The car weighs between 2,200 and 2,500 pounds. The light touring car differs in no way from the standard touring car except that it is lighter, has less power and is geared to speed of about two-thirds of the speed of the standard touring car.

The standard touring cars are generally designed for seven persons. The motors are four or six-cylinder types, and the power is usually well above thirty horsepower.

Brakes. A brake is a mechanism which is a necessary part of the machinery of an automobile and enables the operator by exerting a slight amount of force on a lever to reduce the

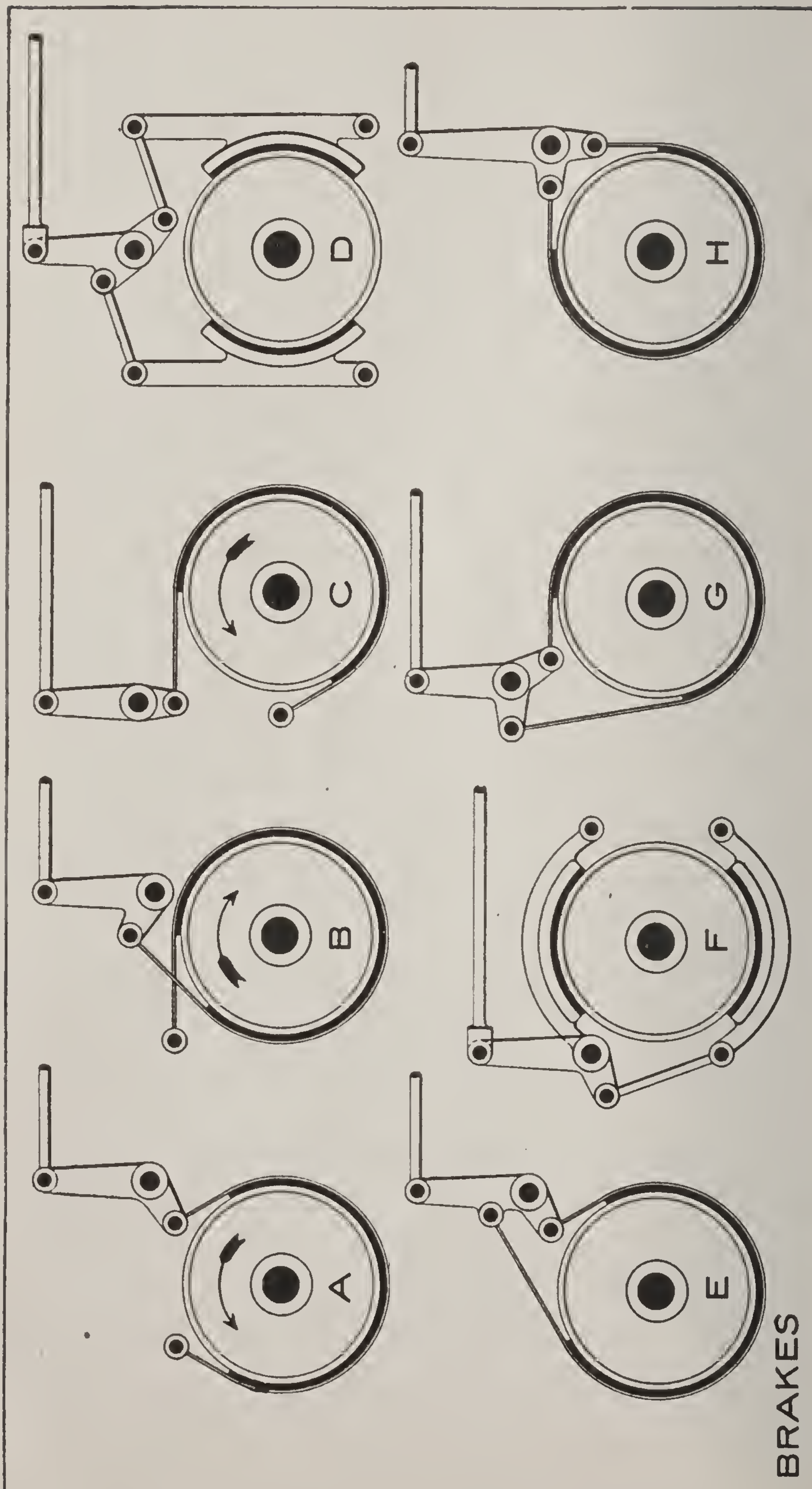


Fig. 55

momentum of the moving car. Brakes used on automobiles may be divided into three classes: Hub or rear wheel brakes, transmission and differential gear brakes. Brakes have also been applied to the tires of the rear wheels, but have proved unsatisfactory and have been abandoned. The forms of brakes in use are single, or double-acting, foot or hand operated, and of the band, block or expanding ring types.

Figure 55, at A, B and C, shows three forms of the simplest type of single-acting band-brake. This type of brake can only be operated successfully with the brake wheel running in one direction only, which is indicated by the arrows in the drawing. If the brakes be operated in the reverse direction to that indicated by the arrows the result will be to jerk the lever or pedal out of the control of the operator of the car.

The three forms of band-brakes shown at A, B and C are all of the same principle, the difference being in the location of the fixed end of the brake-band and the shape of the operating lever. Type D is a form of double acting block-brake, which is designed with a view to eliminate any strain or side thrust upon the shaft of the brake wheel which may be caused by the braking action of the device. Types E, G and H are three types of double acting band-brakes, in which the brake may be applied with the brake wheel running in either direction.

Type F is a form of double acting block-brake,

in which the right hand ends of the brake-shoe arms are pivoted to stationary supports, and the left hand ends connected together by means of a link and bell-crank lever as shown in the drawing.

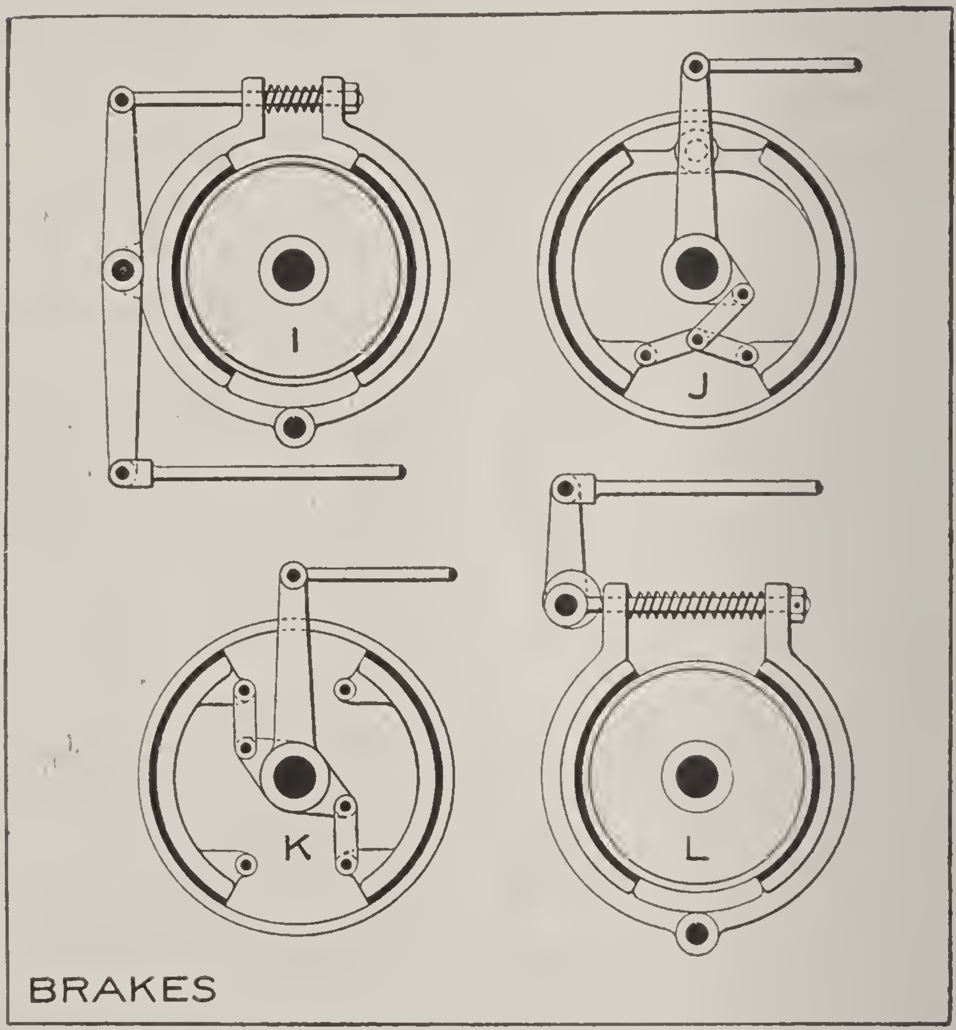


Fig. 56

In Figure 56 a form of double acting block-brake I is shown, which is extremely powerful on account of its peculiar construction, in that is has a double leverage upon the brake wheel, which may be readily seen by reference to the drawing. Types J and K are of the form known

as internal brakes and of the expanding ring type, the brakes operating upon the inner surface or periphery of the brake wheel, instead of the outside. They are known as hub brakes, being usually attached to the hubs of the rear wheels of the car. Type L shows a form of block-brake in which the pivoted brake arms are drawn together by the eccentric located on the brake lever shaft. When the lever is released the brake-shoe arms are forced apart by the action of the coil spring between the upper ends of the arms.

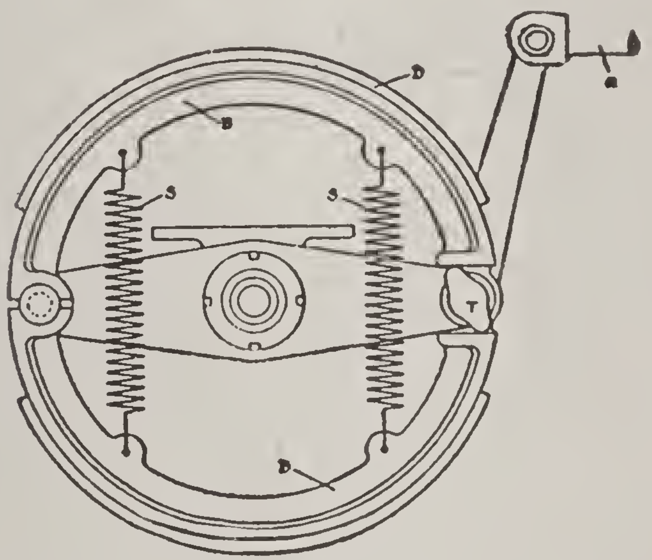


Fig. 57

Expanding Brake. In the internally expanding brake, Figure 57, a hollow metal drum or pulley D is carried upon some continuously revolving portion of the car mechanism, and within this drum are supported two metallic shoes B B, which conform in shape to the inside

surface of the drum by means of a spring, S S. The shoes are capable of being strongly pressed against the revolving inner surface of the drum by means of a cam or toggle arrangement, T, operated through a wire rope or metal rod, R, from the operator's lever or pedal. It is important that brakes of both these types should have their bands or shoes so arranged that an equal frictional effect is produced upon their drums for a given force applied by the operator,

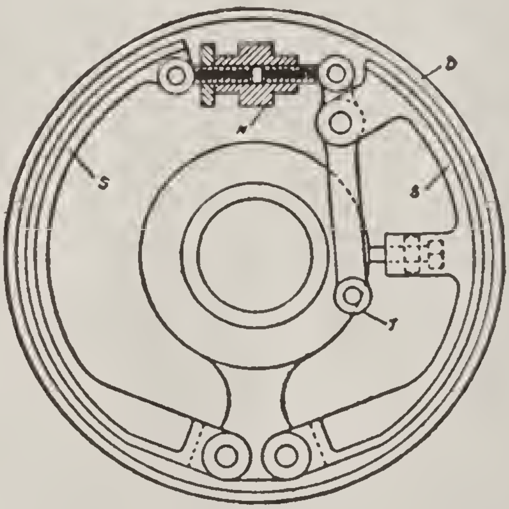


Fig. 58
Expanding Brake

whether the vehicle is running forward or backward. A brake so arranged is said to be double acting. Another type of expanding brake is shown in Figure 58, where D is the brake drum; S S, the brake shoes; T, the toggle arrangement which connects with the brake lever, and N is a nut which is used for adjusting the movement of the brake shoes.

Advantages of the Expanding Brake. The expanding brake is coming more and more

into general use, and is taking the place of the contracting brake in many cases, although the latter is still being used extensively as an emergency brake.

The advantages of the expanding brake are: (1) it is less liable to drag upon the drum; (2) it is easily made double acting; (3) it has more braking power for a given pressure; (4) the friction surfaces are better protected from mud and grit.

Differential Brakes. This type of brake is arranged to act upon a drum forming part of the frame that carries the sprocket and differential pinions. It usually consists of two drums, one of which is fastened to each of the large gears of the differentials. The straps and bands encircling these drums are tightened by pedal, or lever in the usual manner. The disadvantage of this type of brake is, that it can only act equally upon the two drivers when neither wheel slips. Should one wheel slip, the application of this brake would cause skidding.

Brake Linings. For expanding brakes, metal shoes have become standard, owing to the practicability of maintaining proper lubrication between the frictional surfaces. In external brakes the metal band is provided with some form of nonmetallic lining that forms the braking surface applied to the drum. The reason for this is that it is practically impossible to properly lubricate an external brake. Various kinds of material, viz., leather fabric, asbestos,

vulcanized fibre and camel's hair belting, are used for lining external brake bands. A material which is used for this purpose must have great resisting powers, a constant co-efficient of friction, even in the presence of oil and water, and it must have the ability to resist the influence of heat due to the brake's action. In practice it has been found that leather lined brakes burn out, and fibre linings become brittle and cannot be depended upon, so that inorganic materials, which cannot be carbonized, such as asbestos fibre, are widely used. Asbestos fibre may be readily woven into a fabric which answers this requirement, but when used by itself its strength is not sufficient. When, however, it is woven over a metal wire gauze foundation it appears to have the necessary stability to withstand very severe service, and this is the method employed in manufacturing the incombustible brake linings which are being used.

Fibre comes in two forms, hard and flexible. Both are formed from vegetable fibre which has been put through a chemical treatment, by pressure, so that it will not be soluble in ordinary solvents, such as ammonia, alcohol, ether, naphtha, benzine, kerosene and oils. It will swell when placed in either hot or cold water, but when dried out the fibre returns to its original condition. In service it is found very satisfactory as far as wear is concerned, but is not very reliable if subjected to heat.

Leather forms an excellent lining for brakes

of large proportions, but has its disadvantages. It must be kept moist or it will char, and the wear of the surface will be excessive, becoming brittle and breaking off. The kind generally used is oak tanned leather, which has good wearing qualities, as well as a very good co-efficient of friction when used in connection with a metallic drum. It is easily applied, and is comparatively cheap.

Textile linings are very popular and are made in a number of different manners. Ordinary cotton lining is made from four to ten thicknesses of cotton duck stitched together, and is very strong. It is waterproof and cheaper than leather, is easier of application than either leather or fibre, and has a very satisfactory co-efficient of friction. It has an advantage of not charring so readily, and it is claimed that its wearing qualities are better. Camel's hair belting is very suitable, as are also fabrics of which asbestos is the main element, which have great resistance to heat and good wearing qualities.

Cork is the bark of the cork tree, and is the lightest known solid. Its weight is one-eleventh of aluminum, and one-thirtieth of cast-iron. It has a very high co-efficient of friction, and is not affected by many of the conditions which seriously impair the efficiency of other substances.

Cork possesses qualities which distinguish it from all other solids, namely, its power of alter-

ing its volume to a very marked degree in consequence of a change of pressure. It consists, practically of an aggregation of minute air vessels, having thin, water-tight, and very strong walls, hence, if compressed, the resistance to compression rises in a manner more like the resistance of a gas, for instance, than to that of an elastic solid, such as a spring. The elasticity of cork has a wide range and is very persistent. It is this elasticity which makes it valuable when used as an insert in a metal shoe. Cork is of rather a brittle nature, though extremely strong, and for that reason it cannot be used in the form of a lining or facing. The method of applica-cation is to insert corks in holes in the brake provided for the purpose. Cork is not particularly affected by heat or oil, and will largely increase the efficiency in any application to a brake or clutch.

Where metal-to-metal surfaces, with or without cork inserts, are used, the surfaces are usually of different materials. The most common material for drums in all cases is steel, but that of shoes is either malleable cast iron, brass or a bronze. Different metals make a better wearing surface, and some combinations will have a higher degree of friction adhesion than others.

In the selection of material for brake linings, the co-efficient of friction is an important factor to be considered. Table 9 gives the relative values existing in combinations of different materials.

TABLE 9.

Material—	Co-efficient of friction
Metal to Wood	0.25 to 0.50
Metal to Fibre	0.27 to 0.60
Metal to Leather	0.30 to 0.60
Metal to Metal	0.15 to 0.30
Metal to Cork	0.36 to 0.65

EQUALIZERS. In connection with all brakes which are used in pairs, some method is used to equalize the pressure of the brake handle or foot pedal so that the same pressure will be applied

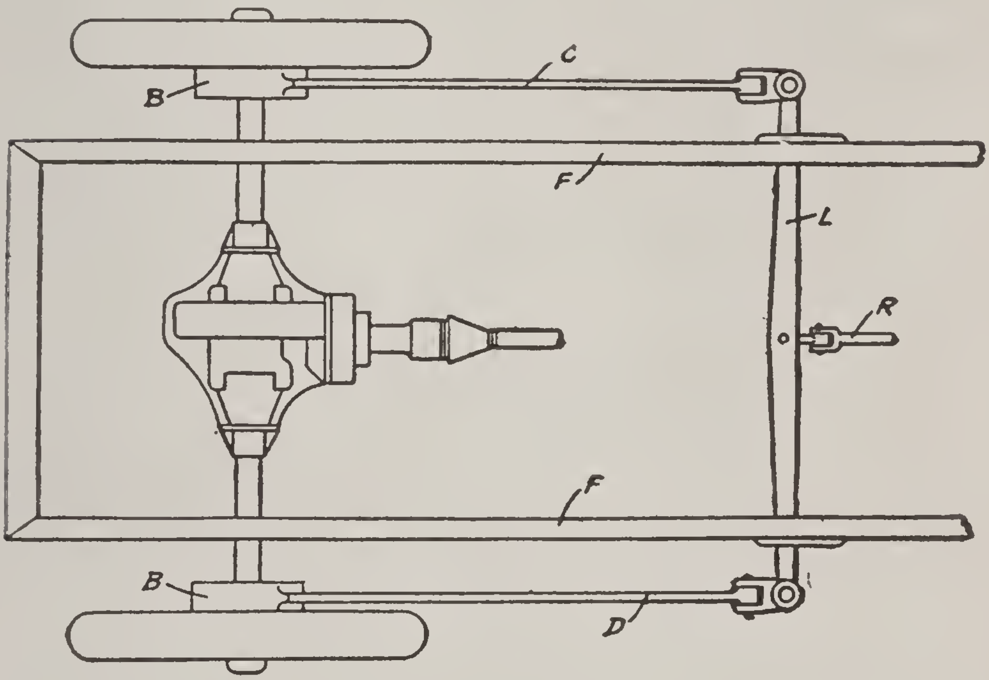


Fig. 59
Floating Lever Type of Equalizer

to both brakes. If the power is not equally applied to each brake, side slip or "skidding" will result.

The different methods of equalizing brakes are shown in Figs. 59, 60, 61 and 62, the majority of cars using what is known as the floating lever type, the cable arrangement being used only on several makes of cars. The floating lever type

of equalizer is illustrated in Fig. 59. L is the floating lever, connected at its central point to the brake lever, or pedal by means of rod R. The ends of lever L are connected to the brakes B, B, by means of the brake rods C and D. When rod R is drawn forward, lever L draws rods C and D forward thus giving an equal pressure on the hub brakes.

Fig. 60 shows another type of floating lever equalizer. Shaft S connects to the brakes by

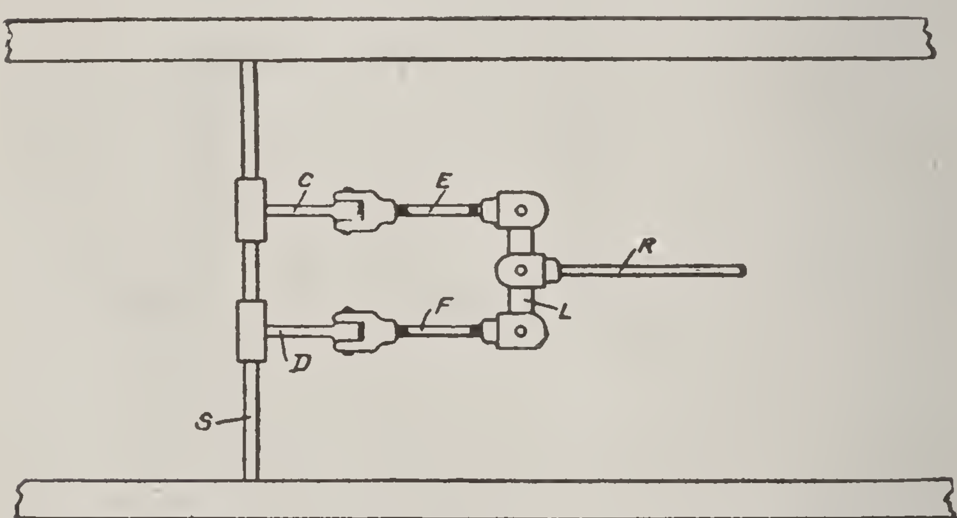


Fig. 60
Floating Lever Equalizer

means of rocker arms located just outside the frame. Two rocker arms, C and D are connected to shaft S, and to the equalizing lever L by means of rods E and F. In some cases the equalizing lever is located outside of the frame. It then takes the form shown in Fig. 61, in which L is the lever that equalizes the pressure on both brakes connected to shaft S. Fig. 62 shows the arrangement of the cord equalizer. Shaft S is connected to the two brakes, one at

each end, and it has two rockers, or cranks E and F attached to it. Parallel to S is another shaft C, which carries a grooved roller R. A cable is connected to crank E, carried over R, and then passing back, is connected to crank F. When R is moved in the direction of the arrow, by the brake lever, the cord distributes the tension between E and F, and as a consequence the brake also. This type is much cheaper than the others, but it requires more care and attention.

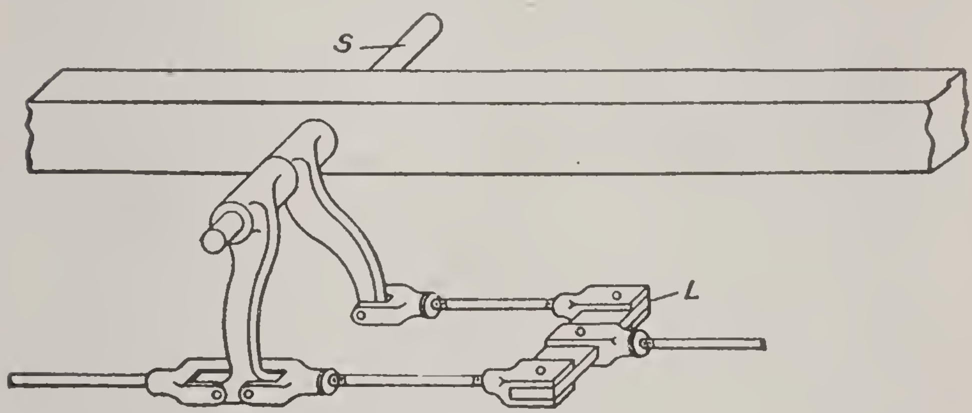


Fig. 61
Equalizer Lever Outside the Frame

SPRAG BRAKE. Sprags are sometimes used on large touring cars. A sprag is merely a strong steel bar, connected at its forward end to some point of the under part of the frame, while its rear end is pointed, and hangs suspended by a chain by means of which it may be dropped to the ground in case of emergency, thus preventing the car from running backwards down hills. A good plan is to allow them to trail on the ground while ascending dangerous hills, and

thus insure their immediate action in case of accident.

A sprag sometimes takes the form of a ratchet wheel and pawl arranged either on the rear axle, on the differential or within the change-speed gear box, so that backward motion of the car is impossible when it is set in action. Ratchet sprags may be arranged to go into action when set by the driver, but a better plan is to have

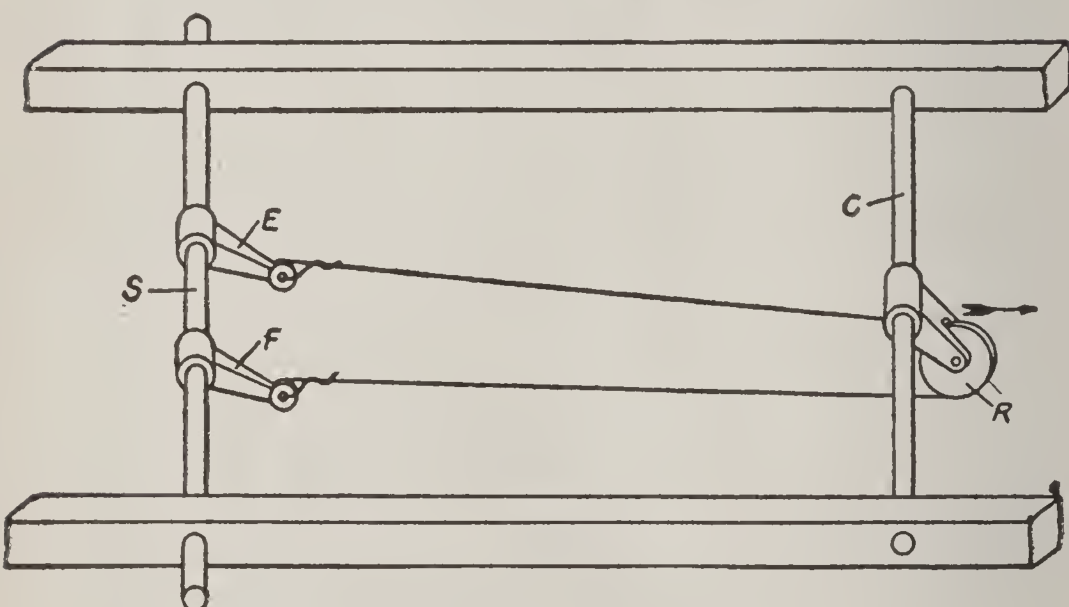


Fig. 62
Cord Equalizer

them so arranged that they will always prevent the backward movement of the car, except when the reverse is thrown in.

Tendencies of Brake Construction. The tendency of brake construction is toward double brakes on the rear wheels, some cars having two flanges with two expanding brakes, others having one flange with a contracting band on the outside, and an expanding band within. The

only exception to these types of brakes is in the use of cone brakes, which, however, is not considered seriously as a brake which must meet all requirements. The practice of using a brake on the propeller shaft is less usual.

Water-cooled brakes are used on several cars, and in others the brake flange has radiating flanges around it to permit cooling by air. The practice of interconnecting brake and clutch is still popular, although some cars have this interconnection only with the emergency brake.

Brakes, Proper Use of. Next to the motive power in importance come the brakes. There are a number of points regarding brakes that every autoist should know and remember. First and most important is the fact that brakes vary in their effectiveness, and that freedom from disaster depends upon the brakes being kept in good condition and properly adjusted. Second, while a brake may be perfectly satisfactory for slowing down, it by no means follows that it will bring a car to a stop as it should, nor hold the car from going backward. Third, brakes should be tested frequently with the car in motion, the pedal or hand lever being applied until the car slows down, or stops. The distance covered in making this test should be noted, and a greater distance allowed in making stops on the road.

In applying brakes, the application should be gradual, reducing the speed of the car as quickly as possible without locking the wheels. As long

as the tires retain their grip on the road, the powerful retarding action of the brake continues, but when the wheels are locked the brakes have little or no effect, and the car will either slide along, or skid, in either case being beyond the control of the driver. Should the wheels become locked while descending a hill, the brakes should be released until the wheels are again revolving, and then reapplied gradually, until they act satisfactorily.

Brakes should be examined at regular intervals in order to ascertain if the lining is in good condition. If worn, the old lining should be replaced with new. If the brakes are of the internal-expanding type, the shoes may have become worn, in which case they should be renewed. Toggle joints and adjusting nuts should be inspected, and any looseness taken up. Brakes should be adjusted on the road, as any improper adjustment of the equalizer bar will have a strong tendency to make the car skid. Both brakes should be adjusted alike, that the braking force applied by the equalizer may be transmitted to the wheels equally.

Brass—How to Paint. First apply a thin even coat of shellac. When this is dry, the paint may be applied in any number of coats desired. The shellac may be colored before applying, and thus lessen the number of coats of paint needed. In this way the job can be completed with one or two coats of paint, and as the shellac will stand a much higher temperature than

will ever obtain in a radiator, it will prevent the peeling off of the paint.

Brazing. Many workmen labor under the impression that a brazing job cannot be done unless the parts are a loose fit, in order, as they say, to allow the brazing material to enter and form a bond. The result is, when they do the work, the parts are a very loose fit, with accentuated shearing tendencies in the section of the brazing material, and if the brazing happens to be poorly done, the result is anything but good, since, in the absence of brazing, there is not even a good mechanical bond.

A good mechanical bond is possible to procure without, in any way, interfering with the brazing process, since the parts, if they are well fluxed, will take a coat of brazing material, even when the recess is but a thousandth or two. In brazing, if the work is to be up to a sufficient standard to use in steering gear, it is necessary to clean and brighten the surfaces in a most thorough manner. This will best follow by mechanical scraping rather than by dipping in some corroding material. Dipping may be of value as a preliminary, but a file, and scraper, in the hands of a man of competence, will go a long ways toward success.

When the parts are well brightened, and the grease is thoroughly removed, by the use of soda water, benzine, or equally good solvents, it remains to flux the parts with borax, and then apply the heat, either by a forge or from a

Bunsen burner; if fire brick, or clay, is used to build up around the parts, the heating process will be attended with less difficulty, and the work will be better at the finish. A rather hard brazing material may be used. This may be purchased ready for use, and there is no reason at all why a motorist of even slight skill cannot make a good job of brazing.

Break Downs, and Their Remedies.

Chain Broken. In case a chain should break, and there are no spare links available, the car may be driven by the other chain, provided the idle sprocket is secured so that it cannot revolve. An easy way to do this is as follows: Pass one end of the chain around the sprocket, secure the end link to the chain with wire, and attach the other end of the chain to some part of the car, as a running board bracket.

On shaft driven cars the universal joint pins sometimes work loose, and drop out. In such cases a temporary pin can be made from a bunch of wire, or by a small chisel held in place by wires, or twine.

Circulating Pump Leakage. Leakage of the water circulating pump occurs usually where the cover joins the pump body by means of a ground joint. A gasket of stiff paper dipped in lubricating oil inserted between the cover and the body will remedy this, the gasket being easily formed with the pocket knife. Asbestos cord is better than paper when treated with vaseline and graphite, but few autoists

carry it. For leakage around the pump spindle the cord can be used, pushing it in with a piece of strip brass or other soft metal so as to avoid scratching the shaft. If no asbestos cord is at hand one of the strands of a piece of hemp rope treated with tallow will also answer.

Cranking with Safety. The principle involved in safely cranking an engine is, to get the explosion at the moment the crank is pulling on the fingers, so that if the kick comes the force will simply pull the handle out of the grasp, instead of being expended against the body weight and applied force. Do not attempt to turn the crank all the way around; adjust it to start against the compression, then give a quick pull upward.

Differential Casing. In cases of emergency where oil or grease cannot be obtained for filling the differential casing, beeswax may be used as a substitute.

Dry Cells for Ignition. Dry cells will give very satisfactory ignition for a four cylinder motor by using four sets of four cells each, connected in series multiple so as to get a voltage of only six colts. By having the vibration respond quickly to the pull of the magnet in the coil, battery consumption will be greatly lessened. The slightest current should separate the contact points.

Gasoline Pipe Broken. When the gasoline pipe breaks, a short piece of rubber tubing forced over the broken ends will do for a short

time, but as gasoline attacks the rubber, too much dependence should not be put on it, and the pipe should be brazed at the nearest shop. If the hole is only a small one a piece of soap squeezed in and held in place by a soaped rag and string will serve if gravity feed is used. For pressure tanks a piece of rubber tubing split lengthwise and well soaped will tempora-

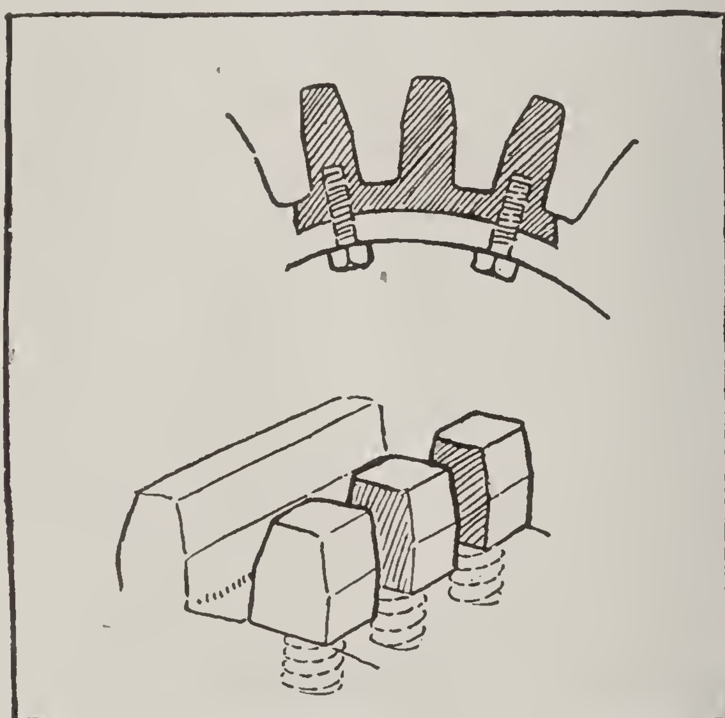


Fig. 63
False Teeth, Permanent Repair

rily stop the hole, if wired tightly around the pipe, but the pressure must be kept low, otherwise the rubber tubing will be loosened and the leaking commence again.

A leak is sometimes hard to locate, but if the pipe is rubbed with soap suds, and then blown through, the leak will be located by the bubbles.

Gear Teeth Broken. If several teeth are

wholly, or partly broken they may be repaired in the following manner; referring to Fig. 63: Shape out a dovetail recess across the face of the wheel, cast or shape up a brass, bronze, or steel segment and dovetail it in, driving it tight from one side, and securing it with screws. Then file the teeth to a template made from the standing teeth of the wheel. For a single tooth proceed in the same way, no screws being necessary if properly fitted and the ends peened over with a hammer; or, file down the broken tooth flush with the bottom, drill and tap two or three holes, according to the width of the wheel, screw in capscrews and trim with a file. It might be well to add, when removing a timing gear for repairs, or any other purpose, care should be taken to see that it, and the gears with which it meshes, are plainly marked.

Miss Fire Cylinder. Should one of the cylinders miss some of its regular explosions at intervals when under a load, it may be located by stopping the engine, and touching each cylinder with the business end of an unlighted match. The cylinders that have been doing their regular work will be hot enough to ignite the match, while the missing cylinder will not.

Nuts and Screws—How to Loosen. Refractory nuts may be loosened by heating, by means of a red-hot piece of iron held on or near them for a few minutes. This will expand the nuts and they will then come off readily. When a screw cannot be readily loosened with a screw-

driver, the latter should be pressed hard into the slot, while a helper applies a monkey wrench to the flat part of the blade. A tight radiator cap can be moved by winding a quantity of twine, or cloth tightly around it.

Priming. If a motor does not start readily, due to not getting a rich enough mixture at slow speed of cranking, tie a small bunch of waste with a wire close to the air intake of the

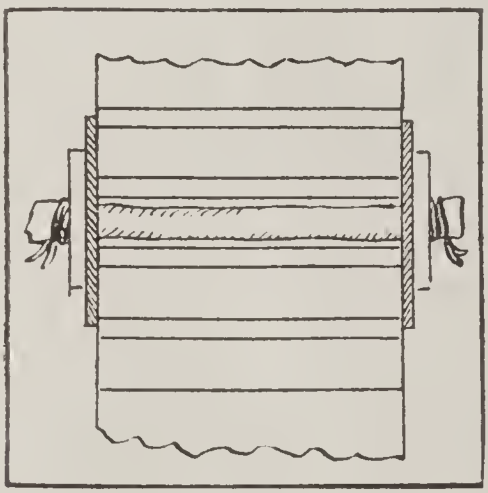


Fig. 64
Section of Radiator Showing Washers Held by Wires on Stick, To Stop Leak

carbureter, then prime by saturating the waste with gasoline. The added vapor will make starting easy.

Radiator Leaking. In case a "honeycomb" radiator starts leaking at the end of a cell, and there is no radiator plug at hand, a substitute may be made by passing a long bolt of small diameter through the defective cell and fitting each end of the bolt with washers made of leather, or rubber backed with iron washers or

metal strips, and then screwing down the nut until the leak is stopped. If a bolt cannot be obtained a small piece of wood may be whittled down to take its place, and the washers secured by means of copper wire as shown in Fig. 64.

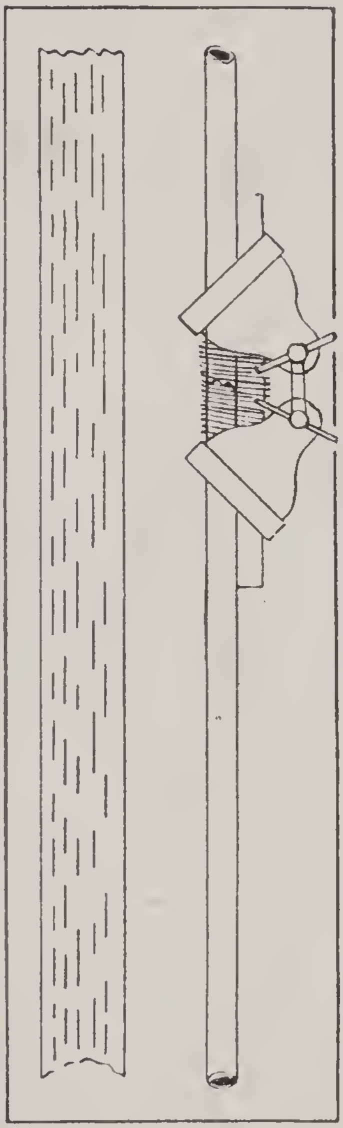


Fig. 65
Repaired Drag-Link, Showing Hand Vises in Place

If a leak occurs inside one of the cells, a square peg cut from soft wood, and covered with a piece of thin cloth smeared with white lead can be used as a plug. Only a moderate force should be used in these methods, as the tubes

are easily buckled. Leaks in gilled radiators may be stopped by applying a rubber patch held in place by tire-tape and wire.

RODS OR LINKS BROKEN. The repair of a broken link in the steering gear can be effected by placing the broken ends together and fasten-

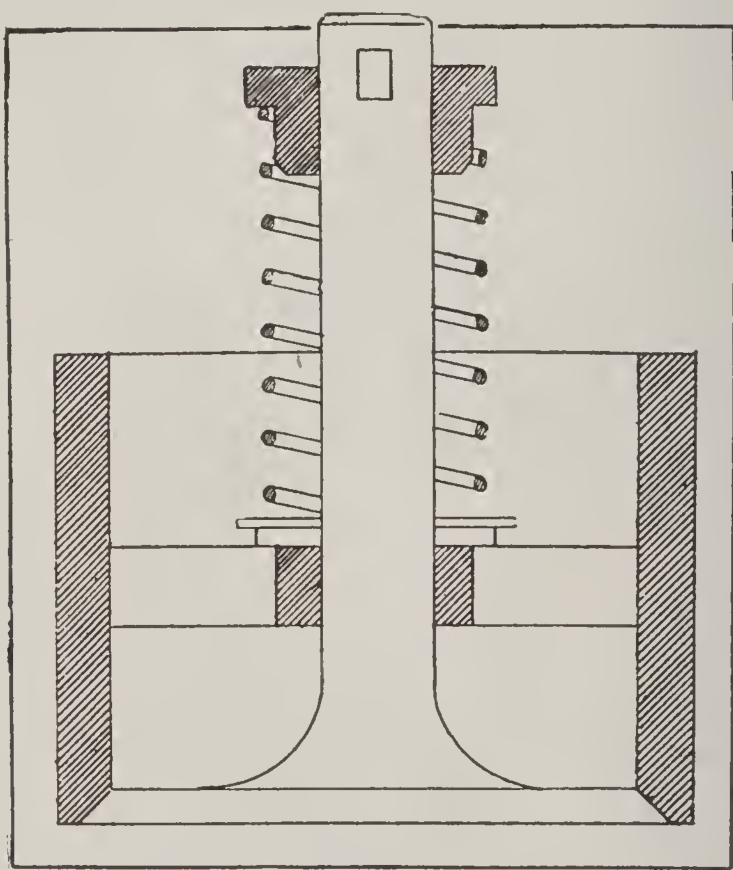


Fig. 66
Valve Spring Strengthened by Inserting Metal Strips

ing a rod or a piece of gaspipe against the link, winding the wire the entire length of the rod. If two hand vises can be obtained they can be attached as shown in Fig. 65. The rod is tied to the joined ends of the link with wire, and the hand vises screwed down on both link and rod. Anything but slow running with either of these

repairs is out of the question. Any other rod can be similarly repaired provided there is room for the pipe or the vises alongside of it. Wire cable can be substituted for brake rods, but the brake must be kept clear of the drum by some means when not in use.

SQUEAKING SPRINGS. A frequent source of annoyance is the squeaking caused by the leaves of the springs having become dry from want of lubrication. When such is the case, jack up the

Fig. 67
Method of Testing Valve Springs

axle until the wheels are clear of the ground, and the springs quite flat. Then with a thin cold chisel, or a large screwdriver, gently force the leaves apart, one by one, and spread a mixture of vaseline, oil and graphite between them. using an old table knife or thin wooden paddle for the purpose. Where parts cannot be reached in this way, oil should be squirted in, and if necessary the leaf clips may be removed to allow of this being done.

TREMBLER BLADES BROKEN. Corset steels may

be used as blades for trembler coils, by cutting them to the proper length, and riveting the platinum button from the broken blade through the hole which is punched near the end. After making the holes for the retaining screw, the blade is complete. A piece of the main spring of a clock will also make a good blade.

Twine is Useful in Breakdowns. Autoists should always carry 15 or 20 yards of strong

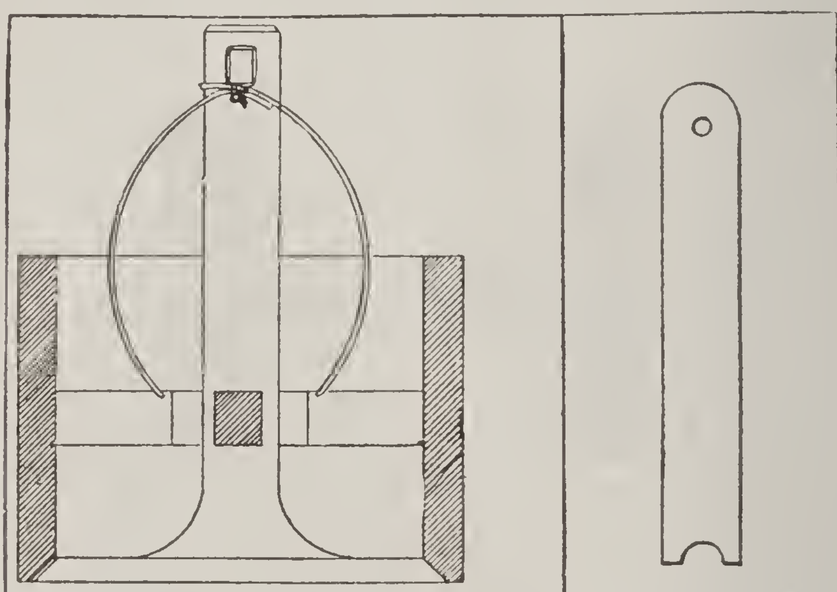


Fig. 68
Corset Steels Used As Impromptu Valve Springs

twine in their kit, as it may be put to various uses about the car, such as reinforcing weak spots in tires, protecting chafed wires, and binding together split sections of the steering wheel. Twine may also be used as a substitute in the absence of a lock washer, by forming a loop slightly larger than the diameter of the nut, and then wrapping twine around this loop, forming a "grommet," as sailors call it. When

the nut is screwed down upon the grommet it will be held as firmly as if fitted with a nut-lock, and will stay tight until the twine rots.

Valve Springs Weak. Mechanically operated inlet valves have generally superseded those of the automatic type, except for two-cylinder opposed motors fitted in light run-abouts and buggies. When the springs on these valves become weak, which they are liable to do, they may be strengthened by inserting thin strips of brass, or other metal between the spring and the spider of the valve cage, as shown in Fig. 66. A spring thus strengthened may be tested against another spring known to be right, by placing the ends of the stems together as in Fig. 67 and pressing the cages toward each other. The metal liners can then be put in place until the valves both unseat equally, indicating that the springs are of equal power. If a spring is broken, pieces of corset steel may be substituted for it, one end of each steel being notched to straddle the spider arm, while the other end is secured to the collar wedge by a wire passed through a hole near the end as shown in Fig. 68. Even if the power of the steels is not equal to that of the regular spring, the motor will run well enough to bring the car home, or to a repair shop.

Various Causes of Break Downs. Any one of the following troubles may be the cause of a motor stopping or not working properly:

Soot or grease on the spark plug.

Defective insulation of the spark plug.
Points of the spark plug too far apart.
Contacts of the coil vibrator badly corroded.
Broken wires or loose battery terminals.
Leaky admission or exhaust-valve.
Seized piston or bearing.
Broken valve-stem or valve-spring.
Batteries exhausted.

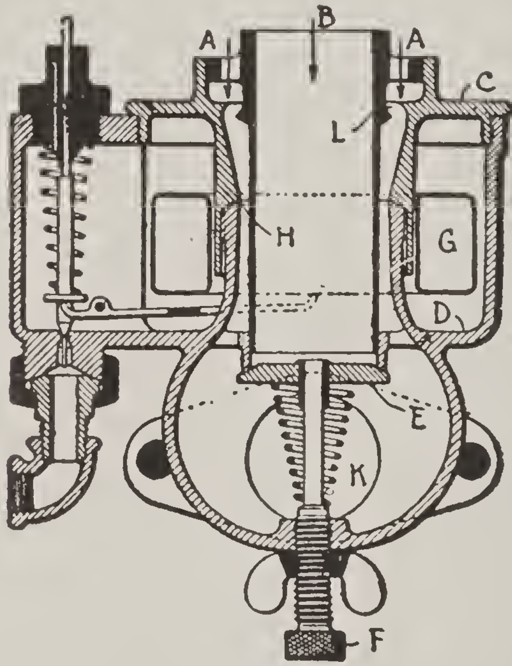


Fig. 69
Brock Carburetor

Defective spark coil.
Poor contact at the commutator.
Defective insulation of the secondary wires.
Broken piston ring.
Stuck piston.
Defective packing.

Brock Carbureter. Fig. 69 is a sectional view of the Brock Carbureter. The float chamber is concentric with the mixing chamber, and

the gasoline enters the mixing chamber through an annular valve instead of through a central spray nozzle. At each suction of the engine a thin film of gasoline moistens the inside of the outer stand pipe, and is simultaneously wiped off by the sheet of incoming air. The central standpipe forms a supplementary air passage, which is controlled by a spring-pressed valve at the bottom, which latter is adjustable from the outside. Air enters through a ring opening A, and flowing downward, as indicated by the arrows, passes a slit opening H in the inner side of the float chamber wall, through which the gasoline emerges. Laden with gasoline, the air continues its downward path and finally exits through the circular opening K. The size of the gasoline opening H is regulated by screwing up or down the top piece C, or cover of the float chamber. The float G maintains a level approximately one-sixteenth inch above the escape slit H, and in adjusting or getting the correct size of this opening the proper method is to screw C down until it seats firmly at H, and then unscrew it about one-eighth of a turn.

The edge of cap C being serrated and marked facilitates this work. All of the air needed cannot enter by the ring opening A, consequently it finds entrance through the vertical pipe B, which is located centrally in the carbureter. The bottom of this pipe is guarded by a spring-controlled poppet valve E, with adjusting screw F.

The needle valve for controlling the entrance of gasoline into the float chamber is located in an enlargement at the side of the float chamber, and the valve is operated by means of a short lever pivoted into the side of the chamber, so

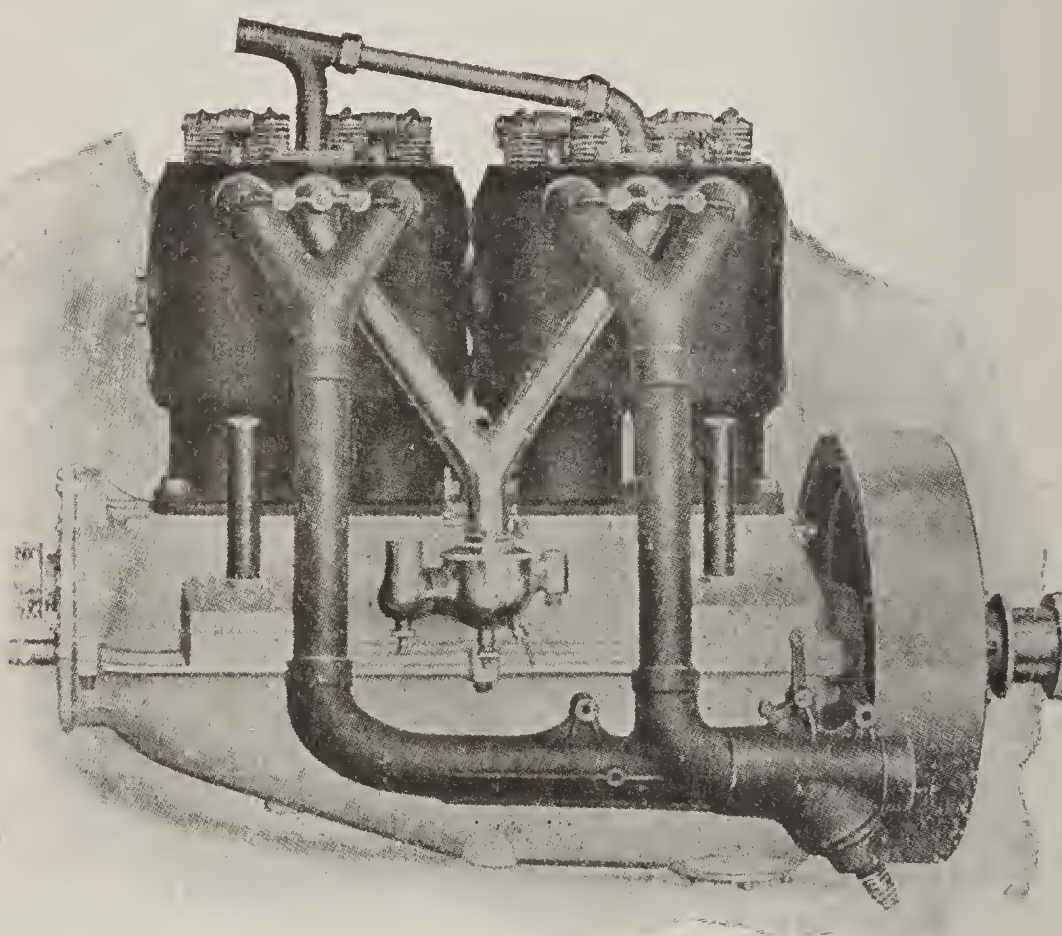


Fig. 70
Left Side of Motor Showing Intake and Exhaust

that a very short arm acts upon the needle valve, and a much longer arm on the float, thereby causing a very delicate float operation and control. Viewed structurally the bottom part of the float chamber B, and the part uniting the induction pipe to the motor are cast integrally,

thereby leaving the top C free for adjusting the flow of gasoline, or for removal in case of cleaning.

Buick Motor. In the Buick Motor the cylinders are cast in pairs, with ample water jacket space on sides and heads. An important feature

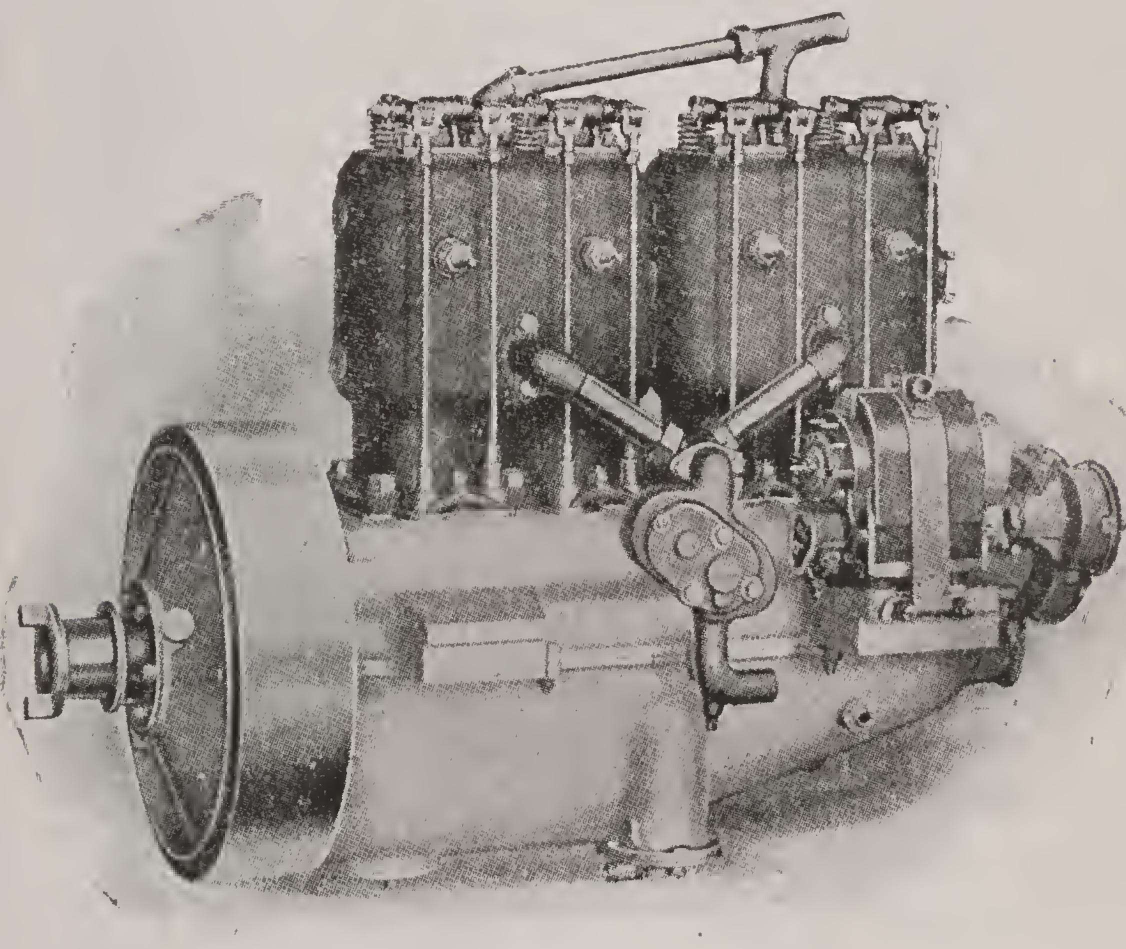


Fig. 71
Right Side of Motor Showing Valve Action

in connection with this motor is, what the builders term the "valve-in-the-head" construction, that is, both intake and exhaust valves are located in the cylinder heads, thus confining to a minimum the volume of burned gases remaining in the cylinders after each explosion, to mix with

the incoming new gas. It is also claimed by the makers that owing to the fact that the power created upon ignition is directly applied to the piston head, the efficiency of the motor is thereby increased. Figures 70 and 71 show respectively

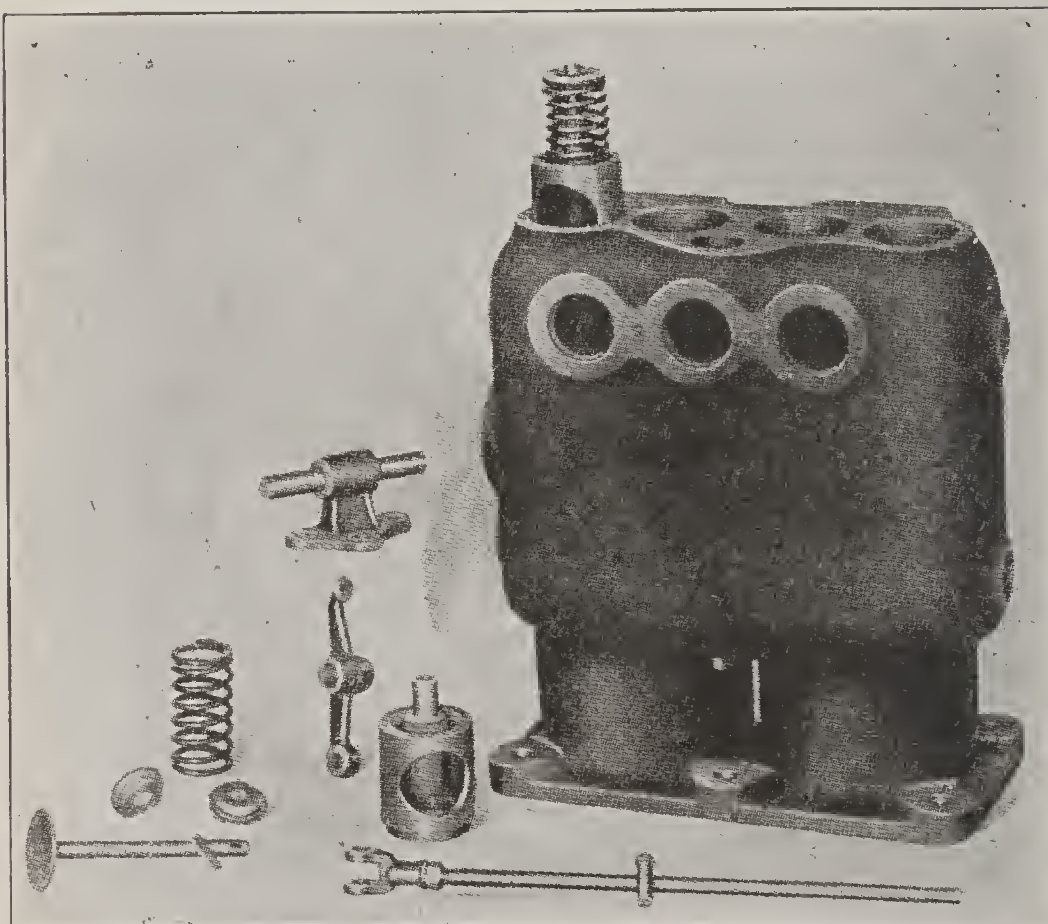


Fig. 72
Cylinders

the left and the right side of the motor, while Fig. 72 shows a pair of cylinders with the parts dis-assembled.

Water circulation through jackets and radiator is produced by a gear pump having capac-

ity sufficient to maintain a fast and free circulation. The cam shaft and magneto gears are enclosed, and run in oil. A single cam shaft serves to operate both the intake and exhaust valves. The current for ignition is now supplied by a Remy magneto, while a reserve set of dry cells supplies the primary current for starting. Both the magneto and battery current travel the same course, after reaching the coil box, the circuit breaker, and distributor section of the magneto being used in either case. The preceding description refers principally to models 16 and 17. Another important feature in connection with this motor is that it is self-starting, the connections being such that by turning the switch over to the battery, and pushing and releasing the starting button, the primary current from the battery is sent through the coil, no matter whether contact is being made by the circuit breaker or not. In other words, it is possible to get a spark at any place in the cycle of the motor.

The transmission is of the sliding gear, selective type and is very compact and strong. Three speeds forward and one reverse are provided. The shifting of the gears is effected quietly, quickly and positively. All parts are made of the best nickel steel, specially treated, rendering them capable of resisting friction and wear, and at the same time so tough as to stand the tremendous strain being put upon them without breaking.

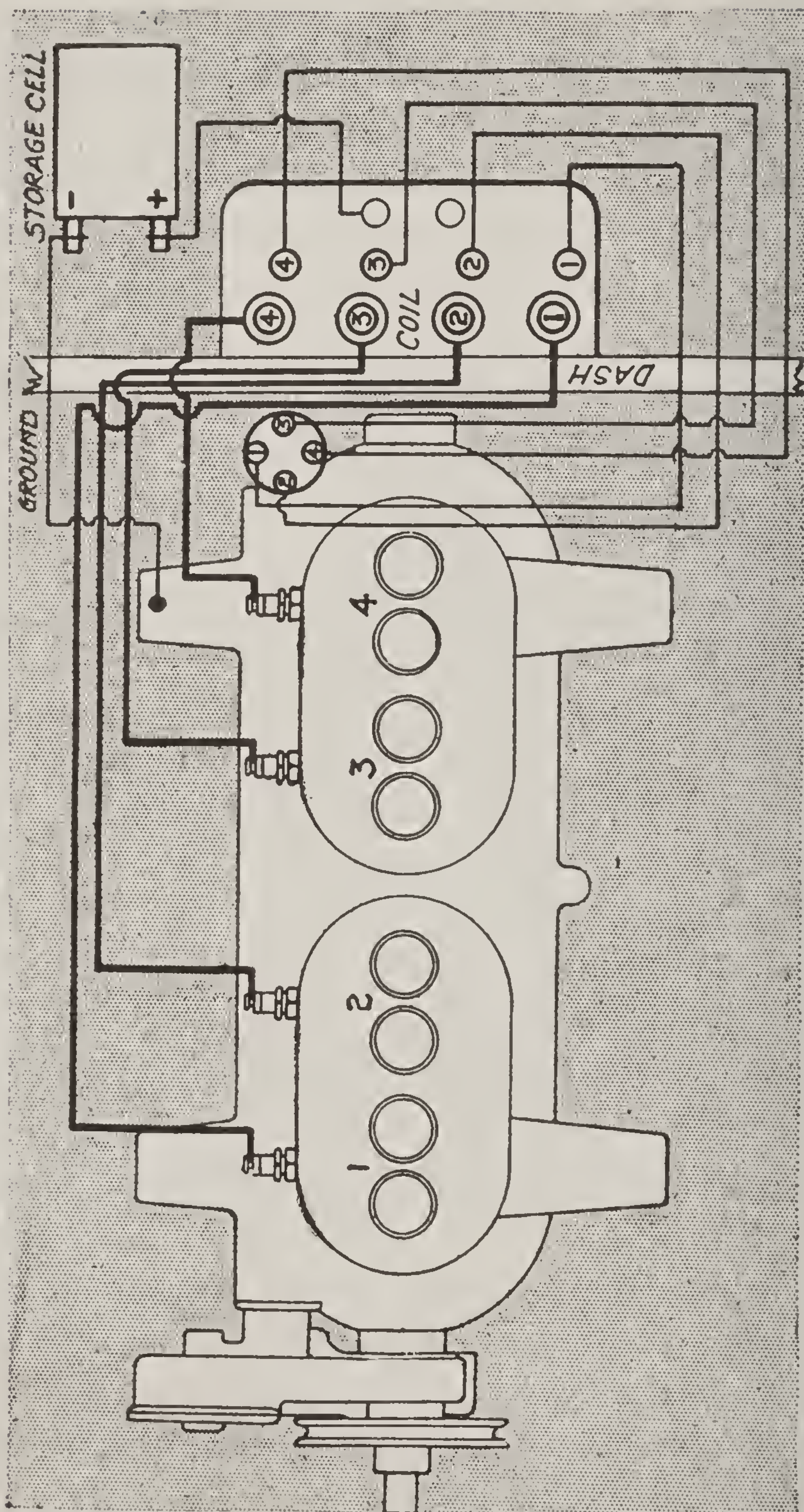


Fig. 73
Wiring Diagram of a No. 10 Buick Motor

Both spark and throttle levers are located on steering wheel, and work on an immovable sector.

Speed changes are effected by means of a hand lever, three speeds forward and one reverse being provided. The emergency brake is applied by the emergency brake lever.

Foot pedals operate the clutch release and service brake.

The emergency brakes are internal expanding on hub and act upon 14-inch drums. These, together with the service-brake, are sufficient for any grade which the car can climb.

Fig. 73 shows a wiring diagram of a No. 10 Buick Motor, and as the coil terminals and plugs are all numbered, any specific directions as to methods of wiring are unnecessary. On the flywheel is a line marked "Center," and 1½ inch from this is another line marked "Exhaust Closes," and approximately ⅜ inch from this is a third mark designated "Intake Opens." To time the exhaust valves, bring the flywheel so that the "center" mark is up, then rotating it until the "exhaust closes" mark reaches the point. This would give the timing for the exhaust valve for say No. 1 cylinder. Bringing the flywheel a complete revolution to this mark would give the timing for No. 3 cylinder, and two successive revolutions would give the timing for cylinders 4 and 2. This would finish the timing of the exhaust valves. The timing on the intakes is identical, excepting that the flywheel is stopped on each revolution at the point marked "intake opens."

Buffalo Carburetor. Fig. 74 shows two sectional views of the Buffalo Carburetor, in which springs and air adjustments are not used, all changes in admission or mixture controls being positive on the command of the operator. Admission of the gasoline is regulated by a cork float which operates a needle valve by means of the rocker arm A having a slot in one end for

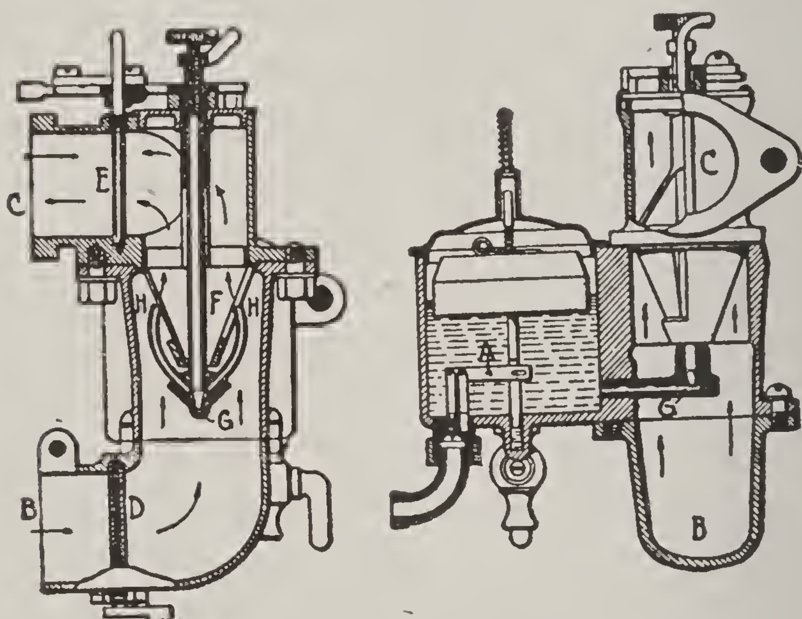


Fig. 74
Buffalo Carburetor

union with the float stem, and a pivoted connection at the other end to the top of the valve stem. The mixing chamber is a vertical air passage at one side of the float chamber, and air entering through a horizontal opening B at its base mixes with the gasoline at a point midway of the height of the chamber, and thence passes through the horizontal opening C at the top. The entrance of the air is guarded by a

starting valve D, the escape of the mixture being regulated by the throttle E. The mixing of gasoline and air is accomplished by the revolving cone valve F. The gasoline enters at the apex of the valve, under regulation of needle valve C, and rises through the bent pipes H. H, having their openings in air ports which may be regulated, in cone valve F. The velocity of the air passing the nozzles may thus be maintained constant regardless of the speed of the motor, the valve being interconnected with the throttle, the interconnection for this purpose being adjustable.

Brush Carbureter. In the Brush carbureter a diaphragm pump deposits the gasoline into a chamber that resembles a float chamber, minus the float. The pump at one end connects with the motor crank case, and at the other side with the gasoline tank, there being interposed two ball valves, one in the tube between the tank and pump, and the other between the pump and the float chamber. On the upstroke of the piston, gasoline is drawn from the tank. and on the down stroke it is forced into the chamber. An overflow pipe leads from the chamber back to the tank, for use when the pump delivers more gasoline than the motor requires. From the chamber the gasoline rises to a level in a standpipe or spraying nozzle, past which an air current flows taking up the fluid. A spring controlled auxiliary air valve is used on this carburetor.

Cadillac Carbureter. This carbureter as used on four cylinder cars is of the float feed type of the usual construction. The type used on single cylinder cars is of a different construction, in which the gasoline is dropped by gravity into a wire mesh, while the air which passes in through the intake tube evaporates the liquid by passing through the film of gasoline formed on the wire mesh. The mixture is then drawn up and through the inlet valve into the combustion chamber.

Camshaft. Fig. 75 is a sectional view of a motor cylinder and illustrates the principle and action of the camshaft. In many motors one camshaft serves to open both intake and exhaust valves, while in other motors there is a cam-shaft for each set of valves. Besides opening the valves, the cams determine the length of time the valves remain open, also the speed with which it opens and closes. Referring to Fig. 75, A is the crank-shaft, P the piston, D is the cam-shaft which carries the cam E. The speed of the cam-shaft depends upon the type of engine. The one shown in Fig. 75 is driven at half the speed of the crank-shaft through the gear wheels B and C, B being one half the size of C. H is the valve to be opened, which in opening must be lifted off its seat. This is done when the cam E revolves and raises the roller G on the lower end of lifter rod F which extends upward resting against the lower end of the stem of valve

H, although between the two rods, or rather at their point of contact are nut and lock-nut L,

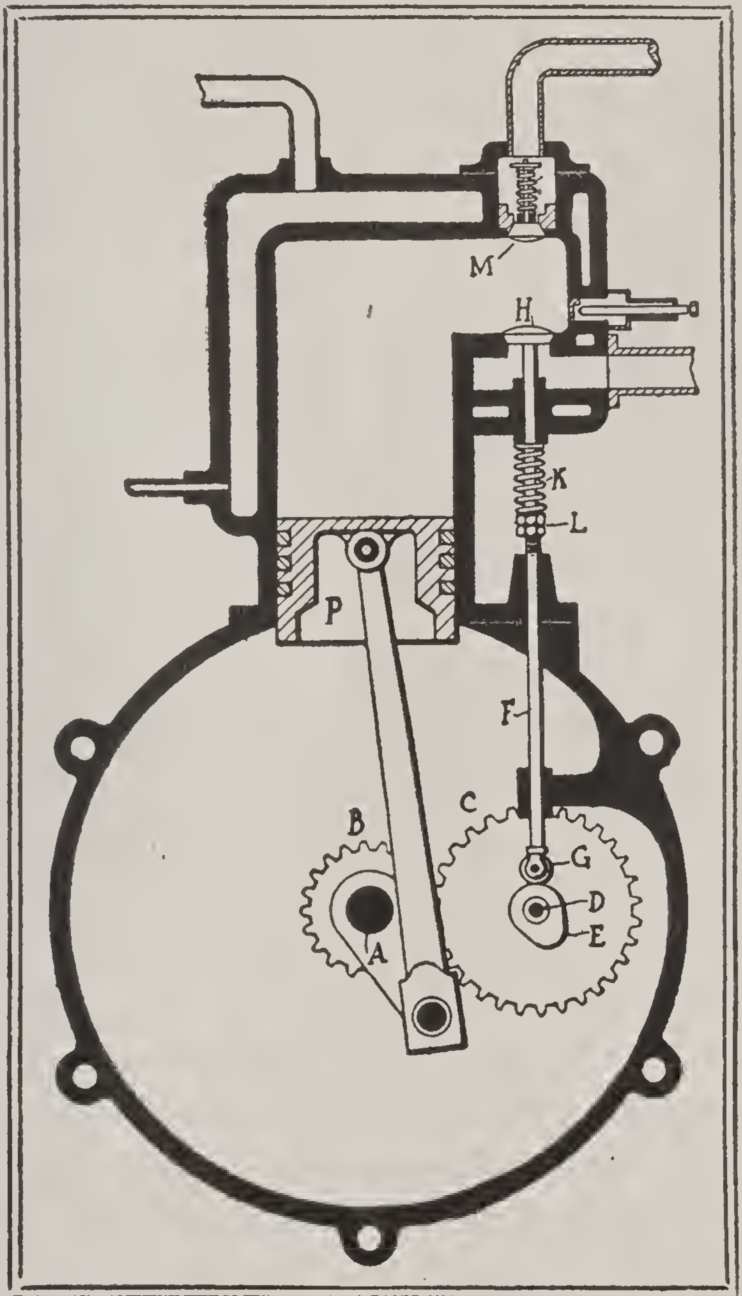


Fig. 75
A Camshaft and Its Location

for adjusting the length of F when timing the valve. K is a spiral spring, the function of

which is to close the valve, after the cam E travels around and allows G to drop. Directly above valve H is the intake valve M, which in this case opens downward. This valve opens automatically, due to the suction of the piston in moving downwards on the intake stroke, but is kept closed during the compression and exhaust strokes of the piston, by the pressure in the cylinder.

Car Inspection. Most autoists are content to make all their inspection of the car and its mechanism from above, and rarely give more than a casual glance below the frame except when trouble occurs. On cars fitted with pressure-feed on the gasoline, the piping should be frequently inspected, on account of the danger from fuel leakage. Such inspections should be made when the motor is stopped, and the pressure still turned on. The tank should be gone over for leaks arising through the opening of its seams from vibration, or the loosening of the union connecting the fuel lead with the tank. The lead and its connection to the carbureter should also be examined for leaks and abrasions due to rubbing against other parts of the mechanism. If any such are found they should be immedidiately repaired. Twine, tire tape, or rubber bands will act satisfactorily as fenders to prevent further mischief. Unions which cannot be made tight by screwing up should be taken apart and the male connections coated with

soap or red lead, which will render them tight for a considerable time.

After going over the fuel system, the brake rods and steering connections should be examined for loose joints and broken oil and grease cups. Grease boots on the drive-shaft joints should be seen to be sound, and filled with grease. A cleaning out of the dirt from the interior of the mud-pan will often reveal lost cotter pins or nuts, and tend to a more agreeable handling of the draincocks, carbureter and filter. This time will be well spent when the chances of fire or accidents arising from faulty steering or brake connections are taken into account.

Carbon Deposit—Symptoms of. One of the most fruitful sources of trouble in internal combustion motors is that of the carbon deposit. If the cylinders get too much oil, or if oil of a heavy or inferior grade is used, a portion of it will work up past the pistons, where it will be evaporated or consumed by the intense heat, leaving a deposit of carbon. This may be augmented by too rich a mixture, which serves to deposit film upon film of carbon on the inside, and top of the compression chamber, and on the head of the piston. The films thus formed will in time commence to scale, and the projections fused by the heat of the explosions will serve to prematurely ignite the charge. The symptoms are back-firing and knocking in the cylinders

—as if the spark were too far advanced. An almost infallible symptom of excessive carbon deposit in the cylinders is the motor showing plenty of power at high car speeds, but deficient in hill-climbing on high gear. At slow engine speeds the incandescent carbon projections serve to pre-ignite the charge, thereby reducing the power of the motor. The cure is to take off the cylinder head and scrape off the carbon deposit from the top of the piston and inside of the cylinder head. Carbon also will form on the porcelain portion of the spark plugs, thereby furnishing a circuit which the high tension current may follow, rather than jump the gap between the points of the plug. Usually only a part of the current will pass by way of the carbon film, still leaving a weak spark at the points, which in open air, when testing plugs, may seem strong enough. This causes intermittent firing. The symptoms are similar to a poor contact commutator. This condition is difficult to detect, for the reason that when the plug is subjected to the usual test of removing from the cylinder and closing the electrical circuit, the spark is seen to jump free and fat between the sparking points. This is because electrical energy which is sufficient to jump between two points ½-inch apart in the open air will jump less than 1/16-inch in the explosion chamber under 60 pounds compression. The causes of overheating in motors may be summed up as follows: Poor oil, insufficient oil, bad mixture, slow spark, ob-

structed water pipe, low water and valves out of time.

Carbureter. Almost any carbureter will give a reasonably good mixture through a limited range of action. Frequently, however, this range is found insufficient for a particular engine. If right for low speeds, it is wrong for high speeds, and vice versa.

The theory of carbureter action as regards the behavior of the gasoline jet under different air velocities is still only partially understood, and has been the subject of a great deal of more or less blind theorizing, based in many cases on wholly inadequate data.

A non-automatic spraying carbureter (i. e., a simple nozzle in an air tube) makes no mixture at all till the velocity of the air stream reaches a certain minimum. Beyond this point, the richness increases with the speed. Dilution from the auxiliary valve is therefore required only when the richness of the mixture exceeds the normal. At this point it should be remembered that, so far as the spray is concerned, there is no difference between a wide open throttle at slow engine speed (as for instance, up hill) and reduced throttle with high engine speed. The spraying action is concerned only with the velocity of the air past the nozzle before the throttle is reached.

Almost every carbureter is provided with a needle valve controlling the spray orifice. With

this provision it is very easy to determine whether or not the carbureter is doing as well as it should at either low or high speed. For example, suppose that we start with an adjust-

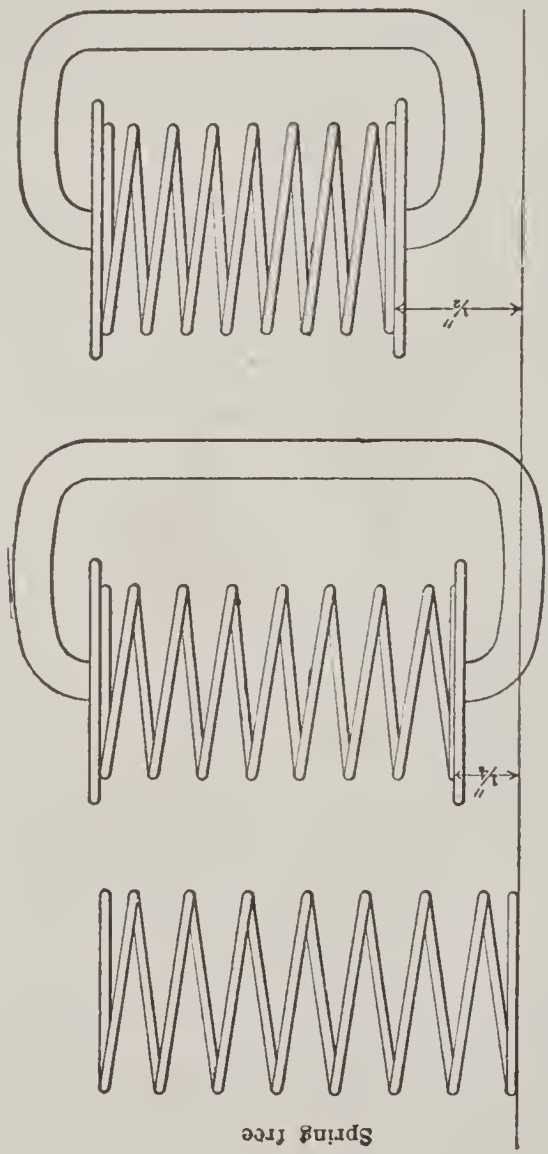


Fig. 76
Carburetor Springs Shown in Three Positions, First, Free, Second, Partly Closed, and Third, Compressed One-Half Inch

ment known to be satisfactory for medium speeds. If the low speed performance is under suspicion, it is only necessary to increase the needle valve opening slightly to ascertain

whether starting is thereby made easier, and a walking pace more smoothly maintained. If overheating results, reducing the needle opening will probably cure it. Similarly slight changes in the needle opening, without changing any other adjustment, will determine whether or not the mixture is improved by

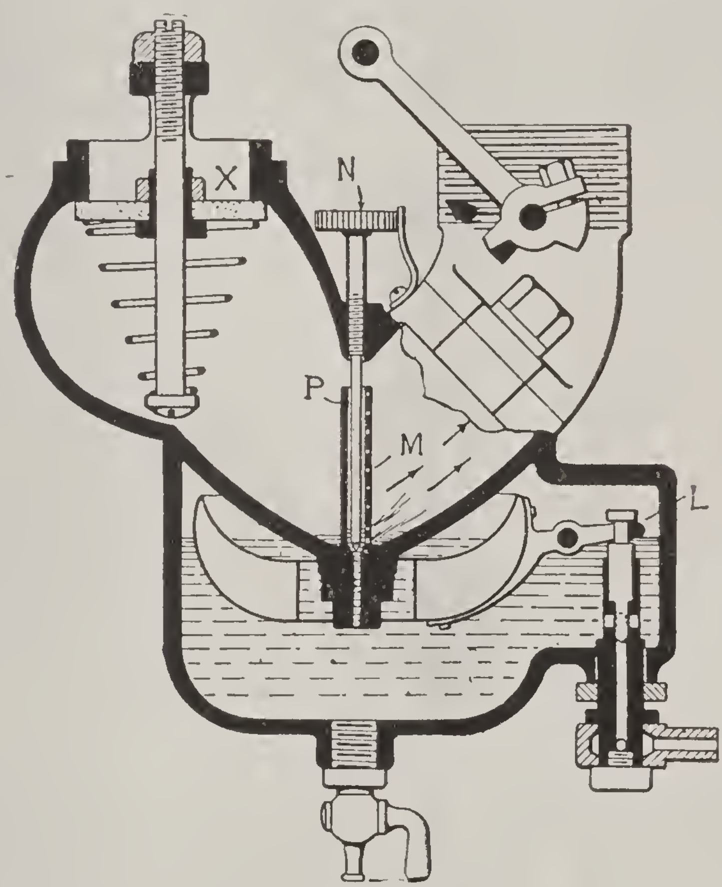


Fig. 77

less, or more gasoline at high speed. When the carbureter is set for a medium speed, if the mixture is weak at low speeds, and rich at high speeds, more air should be admitted, but if the mixture is rich at low speeds, and weak at high, less air should be admitted. Much depends upon the spring.

It is a characteristic of all springs that their flexure is in direct proportion to the load imposed, up to the elastic limit of the spring. Thus, referring to Fig. 76, if the spring represented unloaded compresses ¼-inch under a load of 2 ounces, it will compress another ¼-inch under 2 ounces more, an inch under 8 ounces total load, and so on.

Carbureter—Bennett. In this carbureter the nozzle is a standpipe P, Fig. 80, with a series of

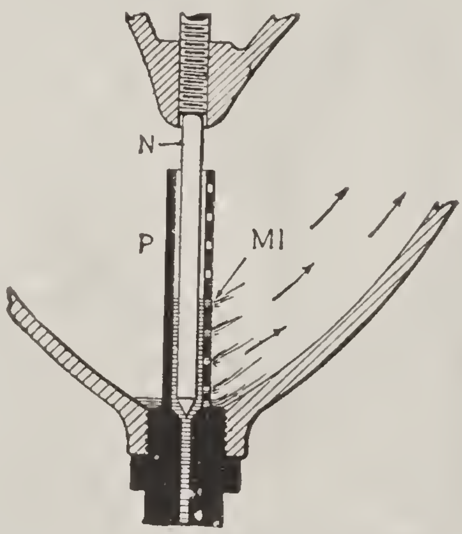


Fig. 78

openings H at one side, so that with greater motor speeds the gasoline rises from this standpipe and escapes from two, three, or perhaps all of the openings H, whereas at slow speeds it escapes from but one or two. Diagram M, Fig. 77, shows the gasoline escaping through some of the base openings at slow speeds, M1, Fig. 78, shows it escaping from half of the openings at half speed, and M2, Fig. 79, shows it escaping from all of the openings at full speed, during all

of which time the gasoline level in the float chamber remains at the point L, Fig. 77. The escape of gasoline throughout the entire height of the standpipe P is made possible by having the part of the needle valve N, Fig. 77, within the standpipe of smaller diameter than the pipe, thereby leaving a circular space for the gasoline to rise in. The air control of the carbureter is through an auxiliary air valve X, Fig. 77, under spring tension. The main air supply for the

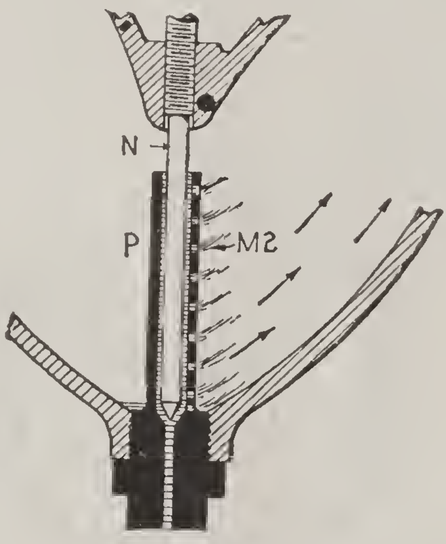


Fig. 79

low speeds is through opening A, Fig. 80, at which time the auxiliary valve is closed. At half the motor speed the auxiliary valve is partly opened.

Carbureter Control. There are various methods of controlling the carbureter from the seat, as it is claimed that the best automatic carbureter cannot adapt itself to changes in gasoline density, or in humidity, or to the gradual warming up of an engine started from "cold." The

arrangement used on the Holley carbureter is shown in Fig. 81. A rod connected by universal joint to the needle valve passes through the dash and ends in a graduated ratchet-held dial. The car is brought up to its proper speed either on the road or on a hill, and the handle is turned to the right or left until the motor pulls

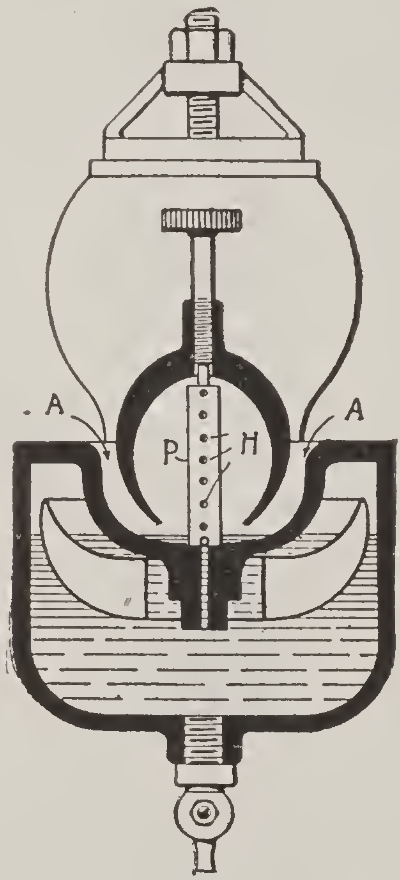


Fig. 80

the strongest. The float level on the Holley carbureter when once set is never changed, adjustments being made exclusively by the needle valve. In the Ford control, Fig. 82, the needle valve is controlled by a rod R, having a forked lower end which enters the large adjusting nut on the top of the needle valve stem. The upper

end of rod R passes through the dash, and has a hand wheel for adjustment purposes.

Fig. 83 shows the Mora carbureter control, in which the main air opening A is controlled from the dash of the car by means of lever L. This lever works in a semi-circular rack, and is connected to ring piece R, which encircles the carbureter above the chamber. This ring has a series of oblong slots through which the air

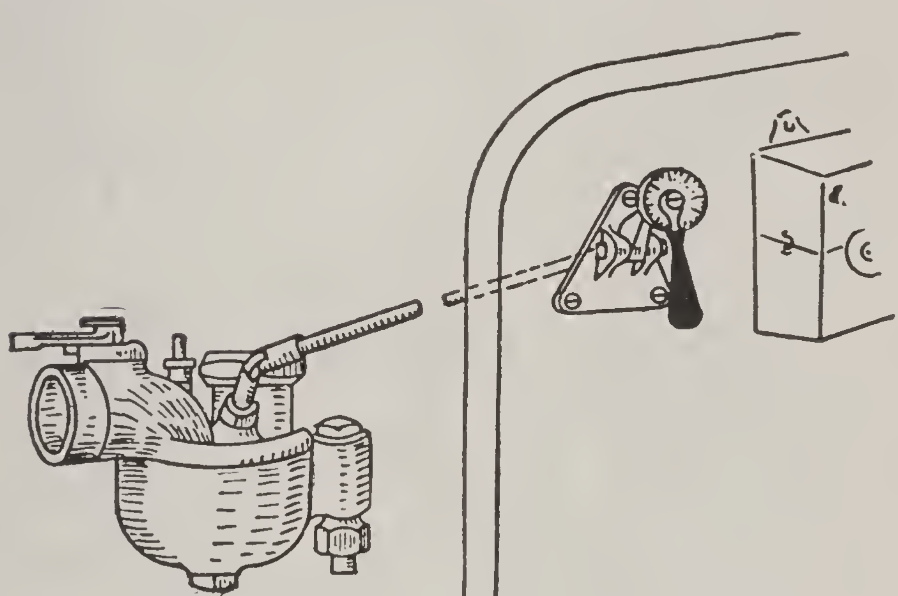


Fig. 81
Holly Carburetor Control

enters. By partly rotating the ring, these slots can be made to coincide with similar slots in the walls of the carbureter, thus regulating the air supply. Air auxiliary valve X is controlled by a spring.

Carbureters—Classification of. Carbureters may be classified according to the principles of their action, as follows: First, the surface carbureter, which operates to produce a fuel mixture when air is passed over the surface of a

body of volatile liquid, or when the air circulates around a gauze wicking or metal surface saturated with such a liquid; second, the filtering carbureter, in which air is forced under suction through a body of liquid from bottom to top, so as to absorb particles of its substance; third, the float feed carbureter, in which the liquid hydrocarbon is sprayed or atomized

Fig. 82
Ford Carburetor Control

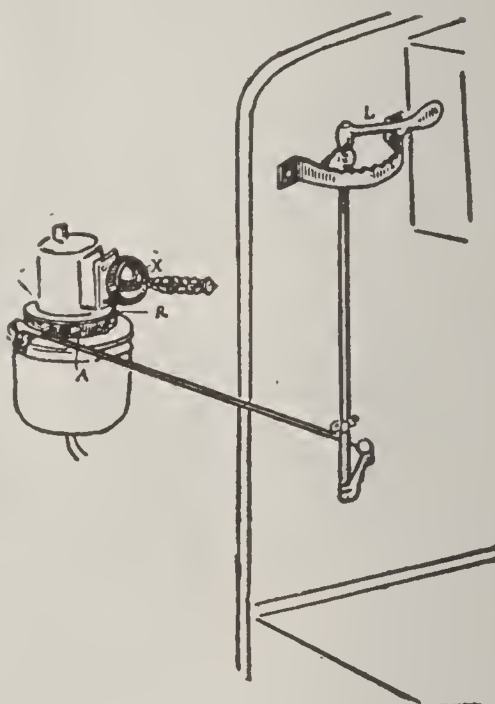


Fig. 83
Mora Carburetor Control

through a minute nozzle and mixed with a passing column of air. At the present time the float feed carbureter using a spraying nozzle appears to be the one most generally in use. Carbureters may also be classified according to types, of which there are four, as follows: (a) mechanical; (b) mechanical, with gasoline puddle in the air passage; (c) automatic; (d) auto-

matic, with gasoline puddle in the air passage. In type (a) the air and mixture passages are opened and closed by some form of mechanism, the size of the passages remaining the same until changed by the operator. It is, therefore, unable to meet and adapt itself to the varying conditions of high speed, slow speed, climbing

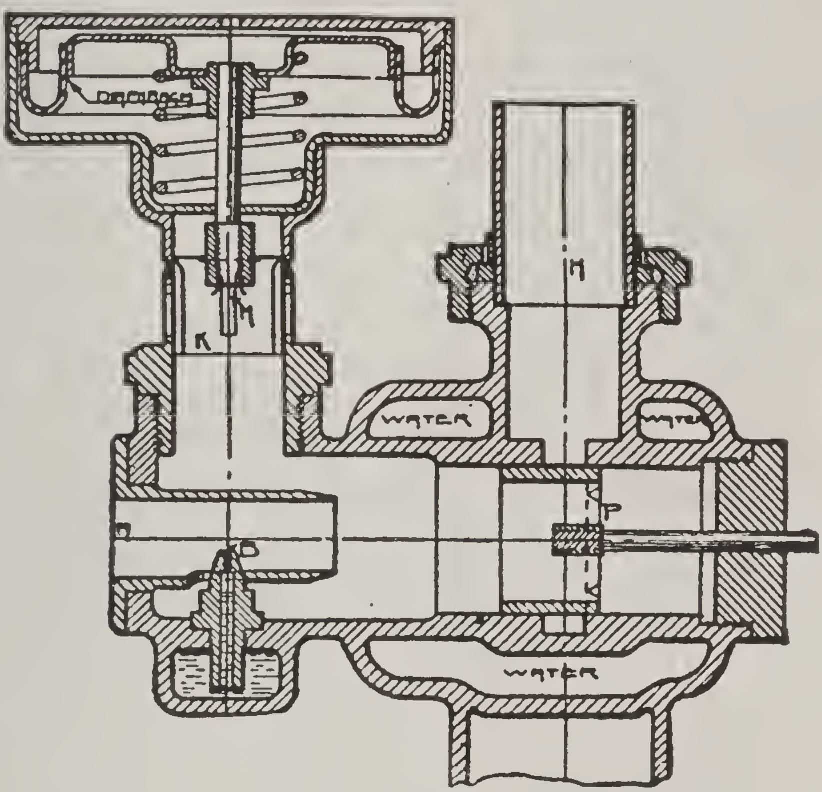


Fig. 84
Automatic Type of Carburetor

hills, retarded spark or diminished suction, unless the operator promptly regulates the size of the passages to suit the requirements of the motor. Carbureters belonging to type (b) use a basin filled with gasoline located in the air pipe. This serves to add a certain quantity of gasoline at all suctions, and thus helps the carbureter when under slow action.

But, as the operation of the machine is not continuous, and the intervals of time between the beginnings of successive strokes vary, according to the speed of the engine, the result is a variation in the amounts of gasoline supplied to the successive charges by the gravity device under the different conditions of fast or slow speed. Consequently the operation of the device is not altogether satisfactory. Type (c), the usual form of automatic carbureter, see Fig. 84, takes a portion of its air through a fixed opening called the main air opening, and a portion through an opening controlled by a valve and a coiled spring called the auxiliary air opening. The main air opening generally represents three-quarters of the total air opening.

A correct mixture having been obtained for the minimum suction on which the motor is capable of running, is afterwards compensated for by the admission of more air, at a rate varying automatically with the suction. As to type (d) a gasoline puddle in the air passage of an automatic carbureter has the same objectionable features as in a mechanical carbureter. There has lately been introduced by several manufacturers an automatic carbureter having a mechanical adjustment for the gasoline needle valve working with the throttle. Aside from the fact that the engine starts up easier, this arrangement is of no advantage, and increases the complications. As the suction varies throughout the intake stroke of the piston, ow-

ing to the varying velocity of the latter in the cylinder, the aggregate of any one charge is made up of mixtures drawn in under suctions, starting from zero, varying in the extreme case up to a maximum and returning to zero.

THE SURFACE CARBURETER is at the present time almost obsolete, being used only on one or

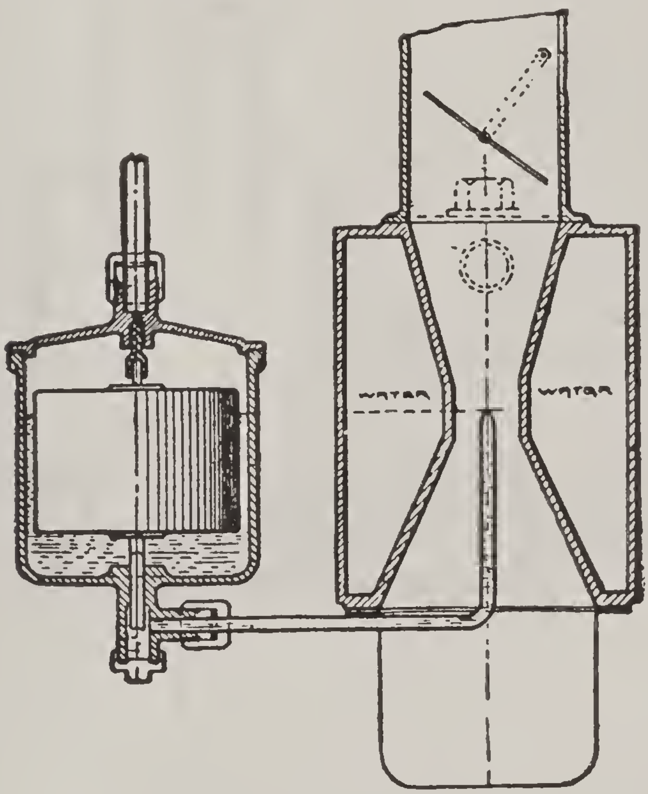


Fig. 85
Float Feed Carburetor

two motor-bicycles of European make. The rapid evaporation of the vapor in the surface carbureter, due to the suction of the motor-piston, causes the gasoline after a short time to become thick and syrupy, and if some external source of heat is not supplied to assist in the evaporation it will cease altogether. While the surface carbureter is the most economical of

the three forms, it is very irregular and erratic in its action, and requires constant manipulation of the air and gasoline vapor cocks to insure at all times an explosive mixture of uniform quality.

The Float Feed Carbureter, Fig. 85, consists of two principal parts: a gasoline recepta-

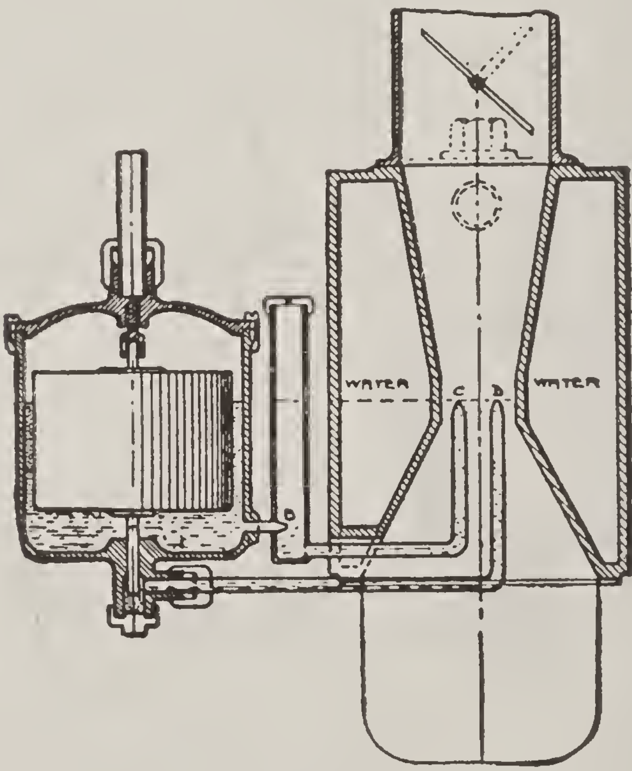


Fig. 86
Multiple Spray Carburetor

cle which contains a hollow metal or a cork float, suitably arranged to control the supply of gasoline from the tank or reservoir, and a tube or pipe in which is located a jet or nozzle in communication with the gasoline receptacle. This tube or pipe is called the mixing chamber. The gasoline level is maintained about one-sixteenth of an inch below the opening in the jet

in the mixing chamber. The inductive action of the motor-piston creates a partial vacuum in the pipe leading from the mixing chamber of the carbureter to the motor, thereby causing the gasoline to flow from the jet and mixing with the air supply, to be drawn into the cylinder of the motor in the form of an explosive mixture.

SPRAYING CARBURETERS. In this type of carbureter the quantity of gasoline delivered is not proportional to the volume of air delivery at different rates of flow. This difficulty has, however, been met by providing a supplementary air inlet to the carbureter, which may be regulated by the driver at will.

Another method of correcting the variations in the proportions of the gasoline charge is shown in Fig. 86, and consists in providing a second spray nozzle. In the majority of cases in which multiple nozzle carbureters are used, there are two nozzles, practically two carbureters, a small one for idle running, and slow speeds, and a larger one for heavy work. In some instances, three, and even four nozzles are used.

THE VENTURI TUBE CARBURETER operates on the principle that if two converging air nozzles have their small ends brought together, there is a point where the suction remains practically constant, therefore if the fuel nozzle be located at this point the result will be, a constant mixture at all speeds. In a carbureter of this type

there are no auxiliary spring controlled air valves, no moving strangling cage, nor any mechanical interregulation between the air, and the gasoline.

An elementary Venturi tube is shown in Fig. 87, which represents the tube A having a head of water on it. The discharge at A is greatly increased by the addition of the divergent nozzle at the outlet end. Under these conditions,

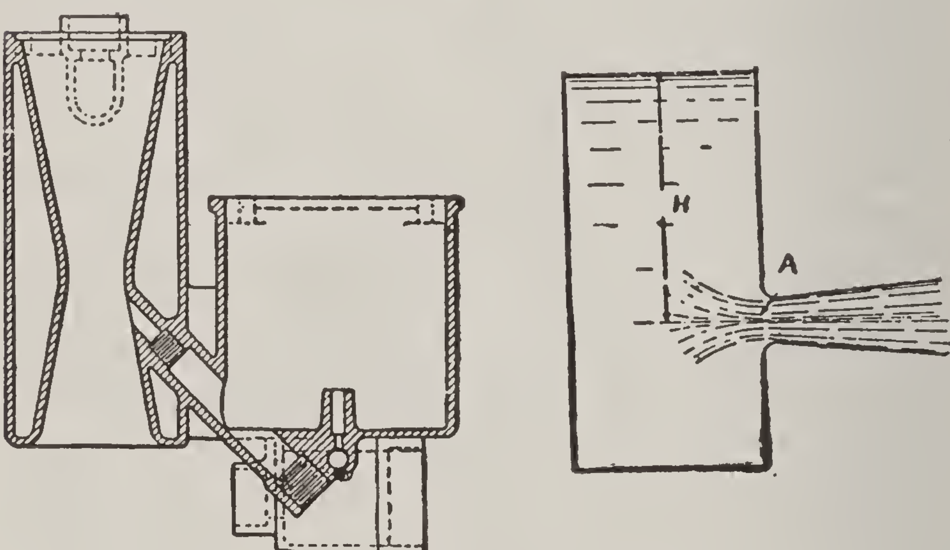


Fig. 87
Principles of the Venturi Carburetor

the velocity of flow in the throat at A is greater than that produced by the head H. When a pressure gauge is placed at A the pressure is found to be less than atmospheric; in fact, the fluid is discharging into a partial vacuum, and the velocity at A is due to the head H plus the head due to the vacuum. Advantage is taken of this fact by placing the gasoline outlet at the point A, in which case the velocity of the

suction controls the flow of gasoline at all times thus giving a perfect mixture.

Carbureters—Inspection of. The float valve of the carbureter should be tested for leaks by opening the valve between it and the tank and looking for gasoline drip. If gasoline escapes, it may simply be because the float is set too high, so that it does not close the needle valve before gasoline issues from the spray nozzle. Or, it may be that the valve itself leaks.

At this stage, it is well to assume that the float is properly adjusted, and to begin by shutting off the main gasoline valve, and then unscrewing the washout plug below the needle valve. It may be found that dirt, waste, or a splinter of wood has got past the strainer, through which, presumably, the gasoline passes on its way to the float, and is lodged in the needle-valve opening. It may be of advantage to open the top of the float chamber, which can usually be done without disturbing other parts, and take out the float and needle valve. A little gasoline washed down through the needle-valve orifice will then generally carry away any dirt that may have clung to the valve when the plug was unscrewed. If the gasoline still drips when the parts are reassembled, the mixing chamber should be opened and the top of the spray nozzle examined to see if gasoline is escaping from it. An electric light should be used in making an examination of the carbureter, as, with any other illuminant, a fire might

be started. The portable electric flashlights sold everywhere at a moderate price answer the purpose very well.

Occasionally a carbureter is found to be too large for the engine, or to have too large a spray orifice. The advice has been given in such a case to reduce the size of the spray orifice by lightly pening the top of it with a hammer. This is counsel of doubtful value, even if the hole be afterward reamed true, since it is manifest that the burr formed in the top of the orifice cannot possibly be deep enough to be at all regular in its form. It will almost inevitably throw a jet slantwise, instead of straight, and this jet failing to strike the main part of the air stream will be only partly atomized, with resulting misfiring and general bad behavior, especially at low speeds. If a new nozzle of smaller size cannot be substituted, the best thing to do in case there is no needle valve to adjust the flow of gasoline to the jet is probably, to warm the ingoing air as much as possible, in order to make evaporation by temperature take the place of atomizing due to the air's velocity.

Carbureter—Scott-Robinson Type. Fig. 88 shows a vertical section of the Scott-Robinson Carbureter. In designing this carbureter M. Scott-Robinson, the inventor, has kept in mind the possible power to be developed by the motor rather than the crankshaft speed; his reasoning being that at times the motor pulls 30

horsepower at 1000 revolutions per minute, 10 horsepower at 100 revolutions per minute, 15 horsepower at 750 revolutions per minute and 15 horsepower at 500 revolutions per minute. from which he deduces that the mixture necessary for the running of this engine must vary according to the horsepower needed, and consequently be independent of the crankshaft speed. It is customary in automatic carbureters to have the mixture governed almost solely by the crankshaft speed, irrespective of the power the motor is generating at the time. In order to achieve mixture in proportion to horsepower the Scott-Robinson carbureter is so designed that it has one jet for every 2 horsepower, so that with the engine working with a 30 horsepower load fifteen gasoline jets are in operation.

Referring to Fig. 88, A is the normal air opening, B the exit to the induction pipe, and C the needle valve governing the flow of gasoline to the float chamber carrying the float F. Within the carbureter proper is a standpipe E, in the top of which is a series of thirty orifices, H through which gasoline can escape. These orifices are in the center of an air regulating float, K which can move piston-like in the casing L. This air-regulating float carries a piston M which fits in the top of the standpipe E, its duty being to uncover and cover the orifices H according as the air regulating float K

rises or falls. In the bottom of float K is a circle of circumferential openings N.

In following the course of the air and gasoline, as well as studying the operation of this carbureter, it should be remembered that the

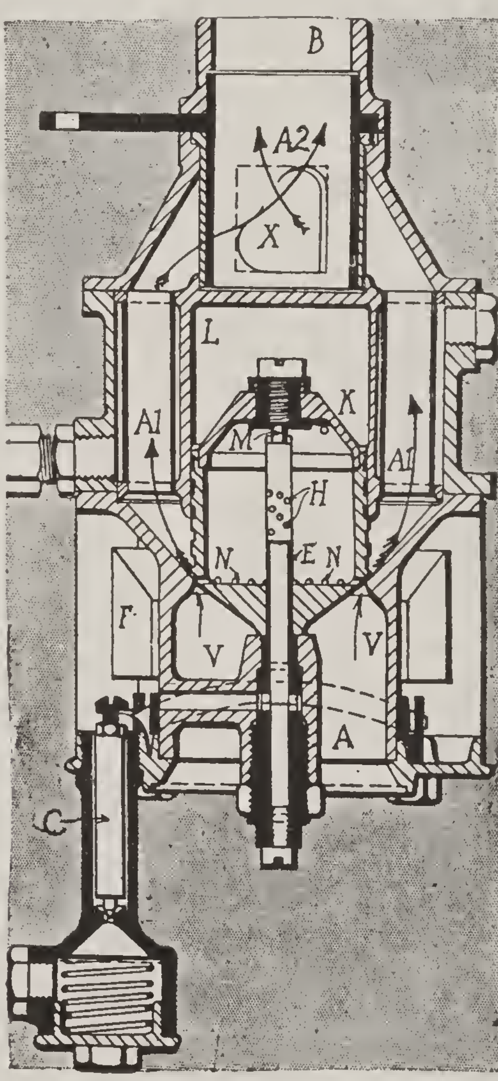


Fig. 88
Scott-Robinson Carburetor

air entering is at first completely confined in the chamber V until the air-regulating float K is raised, permitting the air to pass around this float and follow the direction indicated by arrows A1 and A2. This air, in its course, passes

the openings N in valve K and the suction of the motor is such as to tend to draw the air out of the interior of K. The gasoline can at such times flow out of the orifices H. This gasoline escapes through the openings N, mixes with the air and passes through to the motor. With the throttle X at its half-load position the amount of mixture required would be 1950 cubic feet per hour, at which consumption the float K rises to its half-lift position, bringing half of the orifices H into work. Because the weight of the float K is constant, the velocity of the air past the holes N is constant, and the vacuum within float K is also constant, thereby insuring a constant pull on the gasoline in the standpipe E, which it is claimed eliminates the varying momentum of the escaping gasoline, which is claimed to be so common in carbureters where the pull on it is in proportion to the crankshaft speed. Because the air mixture must always flow past the air-regulating float K, according to the arrows A1 at a constant velocity and the head of the liquid in the standpipe E remains constant, the inventor claims that the delivery of the fuel must be varied in volume only, which he accomplishes in the following manner: Supposing the weight of float K be such that the mixture velocity in the direction of the arrows A1 is 100 feet per second. At a half-load position the area past the base of the air regulating valve K would be .875 square inch, which would be sufficient for 1950 cubic

feet of mixture per hour; or enough to develop 15 horsepower, or half load. Assuming the use of 2 per cent mixture of gasoline, the amount of gasoline vapor contained in the 1950 cubic feet of mixture would make it necessary for the jets to deliver gasoline at the rate of 1.35 gallons per hour.

Should the throttle be moved to its full load position, or 30 horsepower, the air regulating float K immediately rises to its maximum position bringing all of the orifices or jets H into operation. At this position 3900 cubic feet of mixture per hour is needed, calling for a passage area past the base of float K of 1.56 square inches, and a full consumption of 2.7 gallons per hour. Considering the use of a full-powered car, with few opportunities of using the maximum power and, further assuming that the lower orifices H emit up to half the maximum power, they could be adjusted so as to deliver a rather weak mixture suitable for around town work. Also, all jets could be proportioned to give the maximum power at higher loads, which would be suitable for touring purposes. As to the possibilities of clean exhaust under different conditions of this carbureter an analysis showed 1.5 per cent of CO, the analysis being made from a dozen samples. Further evidence as to the operation of this carbureter exists in the fact that an 18-22-horsepower car, weighing 2576 pounds, on a long trip averaged 28 miles to the gallon.

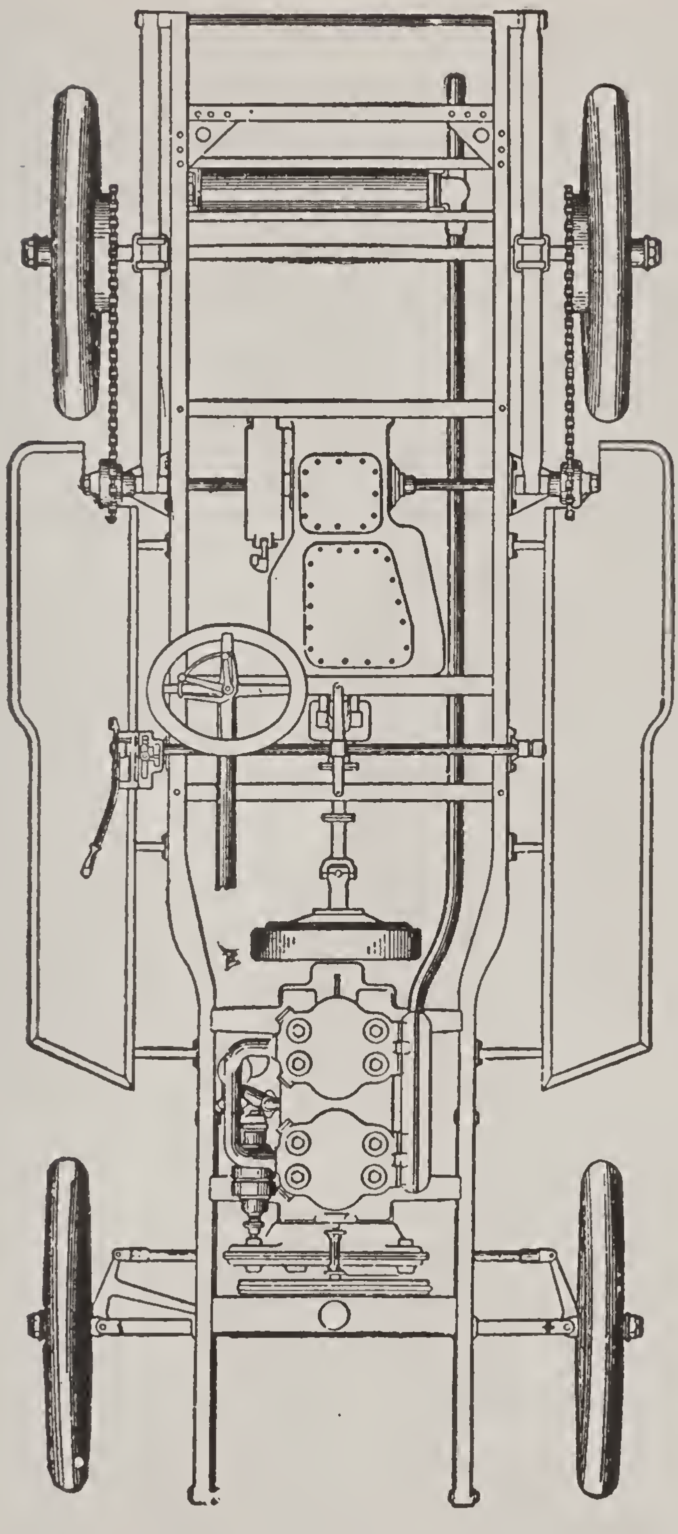


Fig. 89
Plan of Chassis Showing Double Chain Drive

Chain Drive—Double. Fig. 89 shows a plan view of a double chain drive chassis. The rear, or driving axle, is made solid and stationary.

A large sprocket wheel is bolted to the inside of the spokes of each driving wheel, and a cross, or countershaft is carried by the chassis at a point a short distance ahead of the driving axle. The countershaft is divided at or near its central portion, and its two inner ends are connected to the appropriate parts of the differential gear, while the outer ends carry the two small sprockets over which the chains travel. The countershaft usually passes through the speed change gear case. Lubrication of the driving axle bearings is accomplished by packing with grease, or by means of grease cups, or oil holes, the bearings of the counter shaft are also generally lubricated by the use of grease cups. The advantages of the double chain drive, are that being fixed or stationary, it may be given a form most suitable for carrying heavy and variable loads. In this form of transmission the differential gear is relieved from carrying any weight, except its own, and may be arranged to run in oil. The only disadvantages worth mentioning are, that two chains instead of one are required, and that noise of the car is somewhat increased.

Chain Drive—Single. The simplest form of chain drive is the single chain, used on light cars and runabouts. In this type the small sprocket is attached to the engine shaft, and the large sprocket is connected to the rear axle, while the change speed gears are located on the

engine axle, and the differential on the rear axle.

The chain may be either inside or outside the chassis. On cars using the single chain, the driving axle is of the live type, being divided into two parts, to the outer end of which is securely fastened, one of the drivers. At the point of division of the axle, which is usually at its center, the differential gear is placed, to which are connected the inside ends of the halves of the axle.

A steel tube usually encases each half of the axle, and the inner ends of these tubes are brazed to the metal case enclosing the differential. This tube is firmly bolted to the lower portion of the rear springs. It also serves to carry the axle bearings. An underrunning brace is applied to the axle tube on cars designed to carry heavy loads. The disadvantages attending the use of the single chain are, first, that the shaft which carries the load must be divided at its center, and second, there is a constant strain on the rear axle, due to its turning moment. In order to prevent the rear axle of chain driven cars from being drawn toward the engine axle, or countershaft when power is applied to the chain, distance rods or tubes are used, which are adjustable as shown by Fig. 90.

The owner or driver of a chain-driven car should learn very early in his driving career to care for the driving chains in a proper manner. While chains have been known to run an entire

season without any care or additional lubrication, this practice is deprecated. To care for a chain properly, one should get into the habit of lubricating it often, and so time these intervals that they occur before the chain is in need of the oil. In addition to this regular lubrication, there should be some set time at the end of which the automobilist takes the chain off, cleans it thoroughly, and inspects it to detect faults.

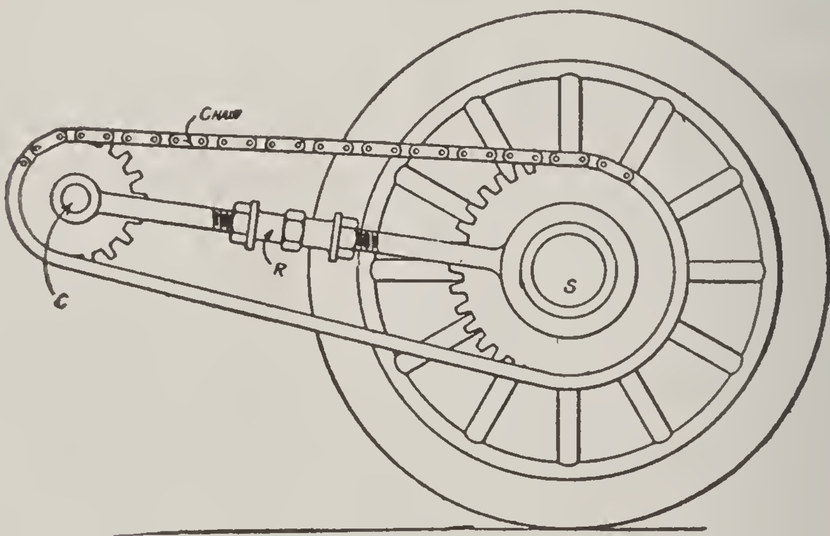


Fig. 90
Method of Tightening and Loosening Chain

A month is a good length of time for this, and an excellent way to proceed is to take the chain off and throw it into a pan of kerosene. In the morning, all of the dirt will have passed from the chain to the liquid, and can be found in the bottom of the pan. Take the chain out and throw the liquid and dirt away. Then clean the pan, and in it wash off all traces of the kerosene with gasoline. Having done this, hang the chain up to let the gasoline evaporate.

The chain then will be both clean and dry. Now inspect all rollers, links, rivets and bushings, taking note of any unusual wear as indicated by looseness or play. If defects are found, they should be remedied. Then, having the chain clean, dry, inspected and passed upon as O K, an excellent method is to soak it, or, better, boil it in a heavy melted lubricant. The best quality of beef tallow mixed with a little graphite is good. Many do not like the latter, in which case a high-grade oil may be substituted for the purpose.

Change Speed Gears. When a gasoline engine is loaded above a certain limit it slows down, and the intervals of time between explosions in each cylinder become so far apart that the engine begins to labor, and will finally stop altogether, unless some means is provided whereby the revolutions of the engine may be increased without increasing the number of revolutions of the driven shaft, or car axle. This is accomplished by means of the change speed gear, of which there are two classes, viz., those in which an infinite series of variations in speed ratio is possible, and those in which only a comparatively small number of step-by-step ratios can be utilized. In the first class are several styles of belt and friction disc drives, while in the second class are the change speed gears proper, namely, sliding gears, individual clutch gears, and planetary gears.

Belt and friction drives constitute the only

practical forms of change speed devices in which variation from the highest to the lowest speed may be possible. In other change speed gears the ratio is changed by passing from one to another in a series of definite steps.

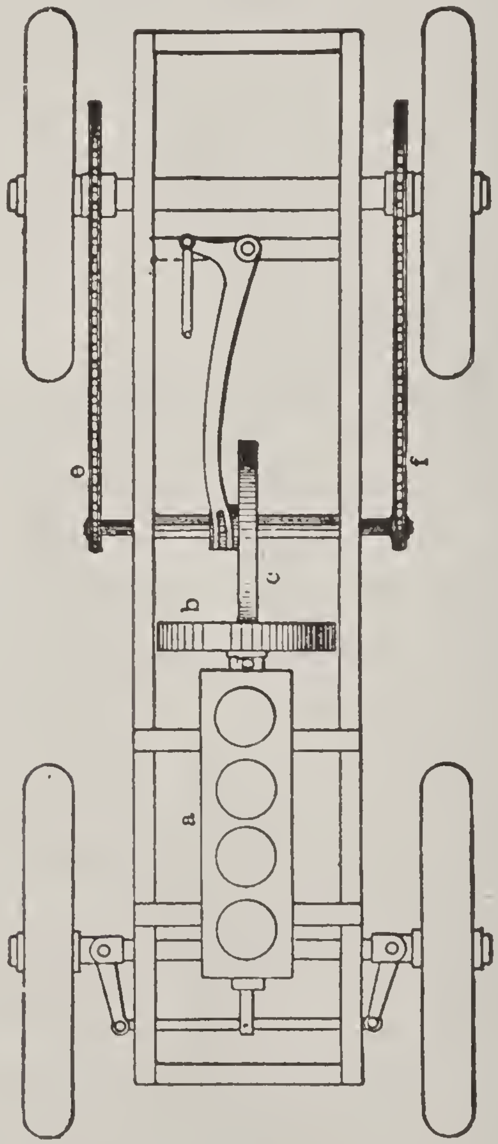


Fig. 91
Friction Disc Change Speed Gear

Friction Drive. One of the most simple methods of changing the speed ratio between the motor and the driven shaft is the friction drive, which in its simplest form consists of two discs at right angles to each other, see Fig.

91, in which b is the fly wheel, the exterior surface of which is made a true plane, and usually covered with a special friction metal. A horizontal shaft located crosswise of the car body carries a friction pulley c, in close proximity to the surface of the fly wheel b.

Friction pulley c while secured from turning on shaft, may at the same time be shifted along at the will of the operator, and thus be brought in contact with any portion of the surface of the flywheel, from its center to its outer edge. The shaft also carries on its outer ends, the sprocket wheels which drive chains e and f, by means of which the power is transmitted to the drivers. In this device if the friction pulley c be brought in contact with the exact center of fly wheel b, no motion will be imparted to c, but if it be moved outward from the center of the flywheel it will revolve, the number of revolutions it makes being governed by its distance from the center. The maximum speed is attained by friction pulley c when it is brought into contact with the surface of the fly wheel near the periphery of the latter. All positions of friction pulley c upon one side of the center of fly wheel b impart a forward motion to the car, and all those on the other side of the center impart a reverse, or backing motion. The traversing movement of pulley c along its shaft is usually produced by a hand lever provided with a notched quadrant, whereby the pulley is held at all times in some one of the many posi-

tions giving graduations of speed. The method usually employed for making and breaking contact between the friction pulley, and flywheel face, consists in mounting the bearings of the cross, or countershaft in swinging brackets. Another method is to mount these bearings in eccentric housings, a slight rotation of which in the bearing brackets will cause the shaft and with it the pulley to approach, or recede from the face of flywheel b. The movement of the shaft toward, or away from the flywheel is produced by a ratchet retained pedal through a reducing linkage, which multiplies the foot pressure.

Double Disk Friction Drive. The limitation of the single disc and wheel to small power, and light loads, has led to the development of the double disc, double wheel type of friction gear illustrated in Fig. 92.

The engine shaft is extended, and carries two disc fly wheels A and B, while friction pulleys C and D are each carried upon one half of the cross shaft which is divided at its center. Friction pulleys C and D are made to slide along the shafts H and F, and are controlled by a common sliding mechanism, so that they always bear upon points of discs A and B, having the same velocities. Driving contact is effected by swinging shafts H and F in a horizontal plane, and it is obvious that if one of the pulleys, D for instance, is pressed against the face of A, it will revolve in one direction, while

if brought to bear on B it will revolve in the opposite direction, thus providing for a go-ahead, or a back-up motion being imparted to either friction wheel at will, dependent upon whether it is in contact with the forward, or the

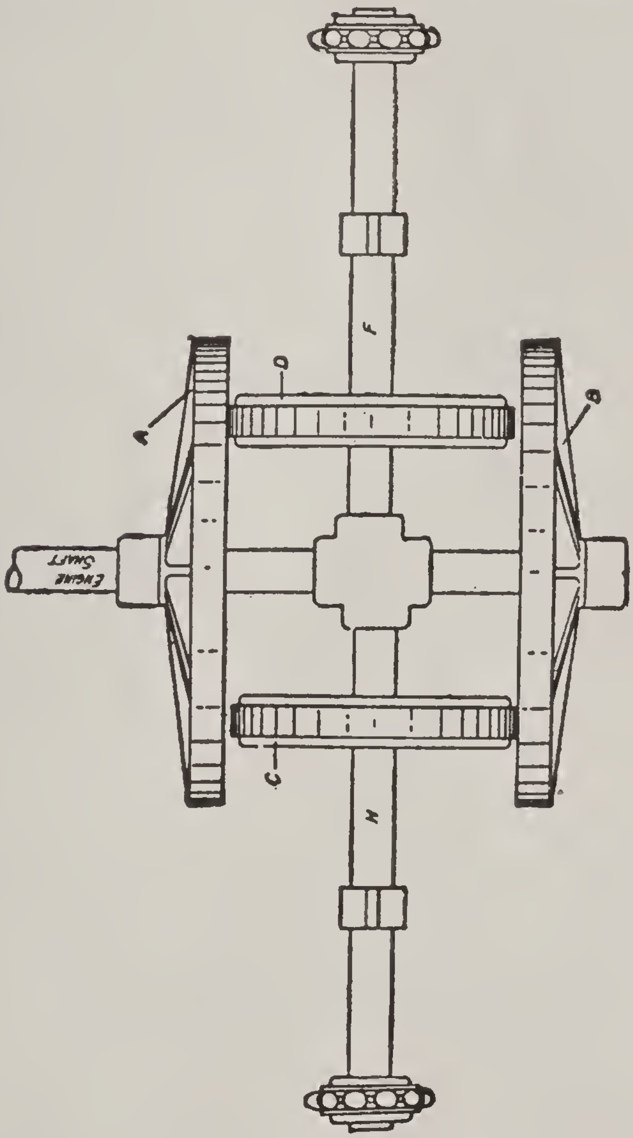


Fig. 92
Double Disc, Double Wheel Change Gear

rearward disc. It is also evident that if one of the wheels, say D, is pressed against A, and the other wheel C is also pressed against B. their shafts will rotate in opposite directions. The ratio of the common angular velocity of the

wheels and their shafts to that of the discs is in proportion to their distance from the center of the discs. Sprockets upon the extremities of shaft H and F drive the road wheels by chains, and sometimes no differential is employed, power being shut off when turning corners, or, if not, the inevitable slip is divided between the frictional contacts, and the contacts of the tires with the road. A differential may be mounted in either shaft H or F at will.

Instead of the two shafts H and F being separate, they may be joined to form a continuous shaft and pivoted in the center. The shaft as a whole is capable of being slightly swung in a horizontal plane about its center, so as to bring friction wheel D in contact with one disc, and friction wheel C in contact with the other, thus producing either the forward or reverse drive. In this case a single sprocket is carried by the shaft and drives a live rear axle.

Bevel Friction Drive. The main objection to the types of friction drive hitherto described is, that they are all subject to more or less slippage. This defect is eliminated by the use of the bevel friction drive shown in Fig. 93. The reason for this is that, when two cones are in frictional contact, their common points of contact will have equal velocities. Referring to Fig. 93, the engine shaft E carries at its rear end a disc flywheel having a bevel rim A, and a plane disc face B. Cross shaft F carries the friction pulley provided with the bevel face D,

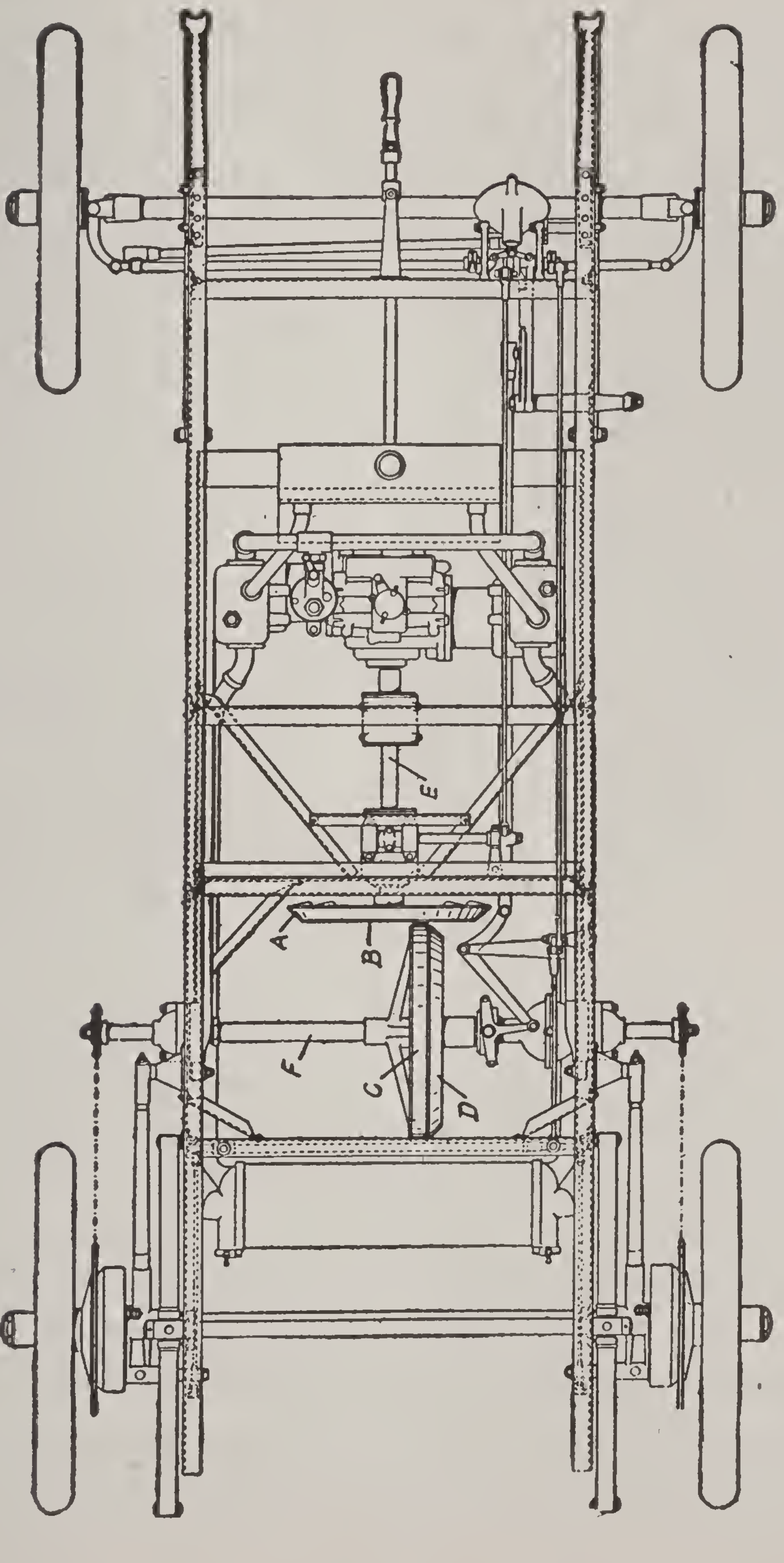


Fig. 93
Chassis of a Two-Cylinder Car Using the Bevel Friction Drive

also the flat cylindrical face C. At low speeds, and on the reverse, this apparatus acts as a single disc and wheel drive, the disc face B being moved backward to bring it into contact with face C of the friction pulley, which is made to traverse the shaft to any desired position. To secure maximum speed, the friction member is moved along on the shaft until its bevel face D is in alignment with the bevel face A of the flywheel which is then moved backward on

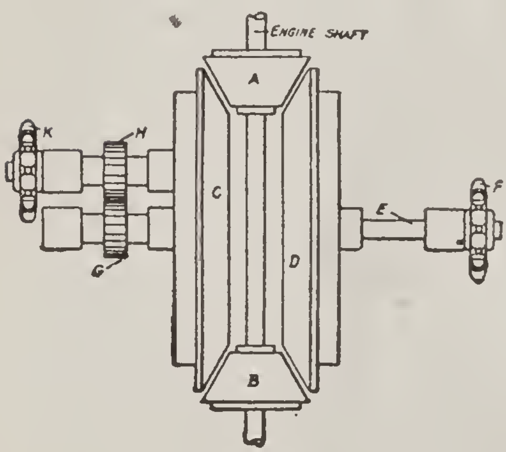


Fig. 94

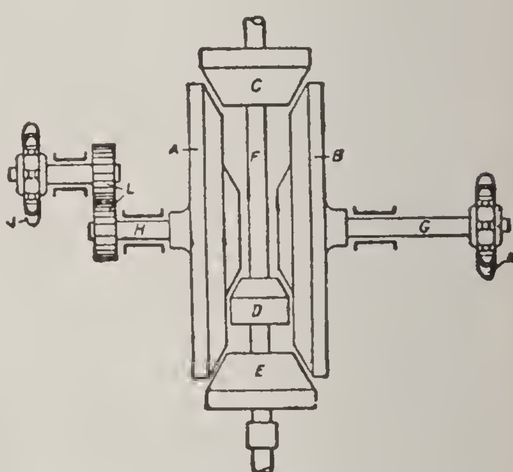


Fig. 95

shaft E until the two beveled surfaces are in close contact. The drive is then practically by a set of bevel gears having an infinite number of teeth, as the two surfaces A and D have a purely rolling action upon each other.

Fig. 94 shows another form of bevel friction drive, in which there are no graduations of speed, except as the speed of the engine varies. The action is as follows: When A is in contact with C and D, it drives at forward speed, sprocket F direct, and sprocket K through

gears G and H. To produce the reverse speed, B is brought in contact with C and D. The friction discs C and D are of gray iron, while the faces of A and B consist of tarred fibre. A stepped friction change speed gear is shown in Fig. 95 in which F is the crankshaft extension carrying bevel pulleys C and E of exactly equal dimensions, and also bevel pulley D of smaller diameter, all three pulleys being slidable on the shaft. A and B are beveled friction discs mounted on the cross shafts H and G, the end of G carrying the driving sprocket K. Shaft H carries one of the pair of spur-gears L, while the other member is on a short shaft which carries sprocket J.

Upon the adjacent faces of discs A and B are formed another pair of bevel pulleys of considerably smaller diameter than the two outer bevel faces, thus permitting of a step upward in speed if desired.

The action is as follows: When E is moved slightly forward on shaft F, it is brought into contact with the large diameter bevel faces of A and B, driving them in opposite directions. But the direction of rotation of sprocket J is corrected by the pair of gear wheels L, the result being a uniform direction of rotation for sprockets K and J.

If pulley D be placed in contact with the inside bevel faces of A and B, the result will be a higher speed, owing to the fact that the diam-

eter of D is nearly as large as the diameters of the inside steps of A and B.

A reverse motion is obtained by bringing pulley C into contact with the large diameter faces of A and B.

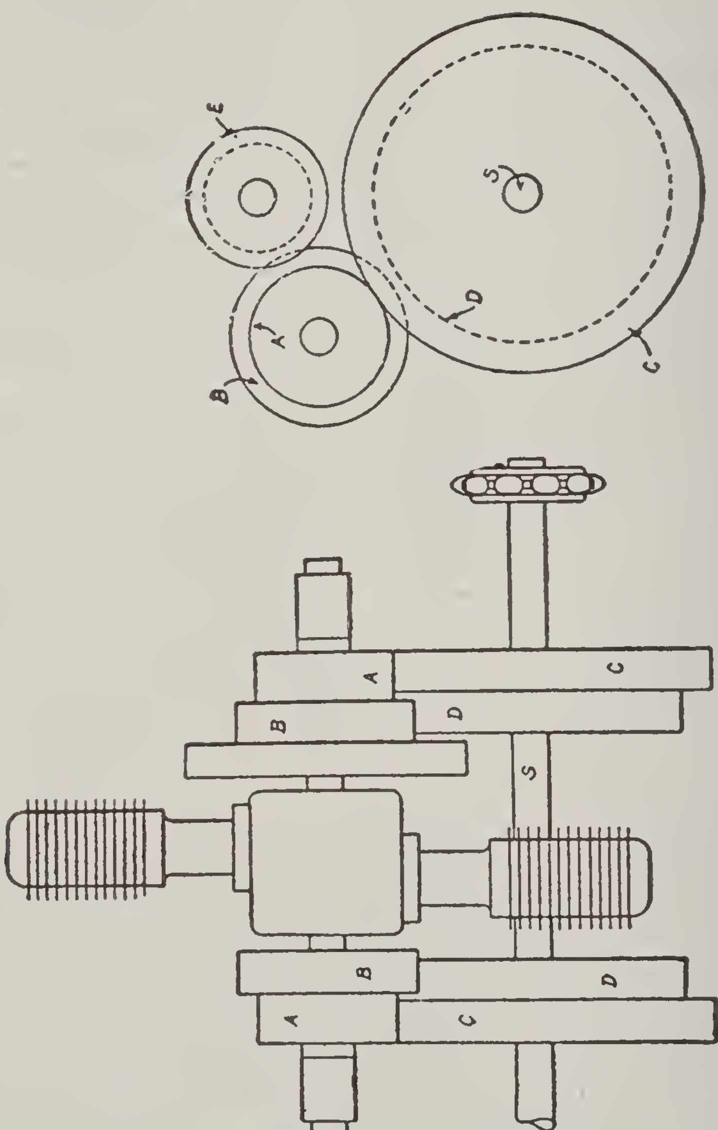


Fig. 96
Pulley Change Speed Gear

Pulley Change Speed Gear. A pair of paper faced pulleys, A and B, Fig. 96, are mounted on each end of the crankshaft. The smaller pulleys of each pair are slidable by means of splines, and are controlled by a foot

pedal, which when operated causes them to telescope the larger pulleys. To the front, and below the engine is a countershaft, S, on which are mounted two sets of aluminum friction pulleys, C and D. Each half of the countershaft is independently controllable. The driving sprockets are carried on the ends of this countershaft. A side lever controls the position of countershaft pulleys with reference to the pulleys on the engine crankshaft. By manipulating the slide lever and the foot pedal the two forward speeds are obtained. The reverse is through a pair of idlers controlled by a second foot pedal, which shifts them into engagement with the low speed pulleys. On account of there being a double set of pulleys and the method of control, no differential gear is used.

Friction Drives—Materials For. In friction drives, one of the surfaces in contact is generally a metal, while the other surface is composed of some kind of organic material, of a slightly yielding or conforming nature. Cast iron with cork inserts may be used for the metallic surface, the cork inserts serving to increase the co-efficient of friction, besides absorbing any oil that may accidently reach the surfaces. Aluminum is no doubt the best material for the metallic surface, on account of its plastic nature. Copper also possesses similar properties. For the non-metallic surface, leather is good so long as oil is kept from accumulating

on it, but its co-efficient drops rapidly as soon as oil gets between the contact surfaces.

Some kind of vegetable fibre, made into a paper or mill board, seems to be the preferred material, and it is comomn to treat such paper with a tarry composition, which tends to raise the co-efficient of friction, as well as to render its value more nearly constant under the influence of water and oil.

The non-metallic friction face is the one worn out in service, or at least it wears the more rapidly. This part of the combination, though of limited life, can be renewed at a comparatively small expense, and it fails only after giving due notice. It is the practice to make the disc face metallic, and the friction wheel rim non-metallic. Great care should be exercised in starting the car, as at such times the disc is liable to slip at speed upon the rim of the friction wheel which is then either stationary or revolving very slowly, and flat spots may very easily be worn upon its surface.

The Planetary Change Speed Gear. This system of transmitting the power at various speeds comprises a high-speed connection for the direct drive, and an arrangement of gears that reduces or reverses the motion when one or another drum on which these gears or pinions are mounted is held stationary. Most planetary systems give only two forward speeds and the reverse, but in some instances they are made to give three forward speeds. They are

used chiefly on small automobiles, or runabouts; but when cheapness of construction is an object they are sometimes employed on touring cars.

In Fig. 97, is shown one form of planetary system. The gear a is the only one keyed to

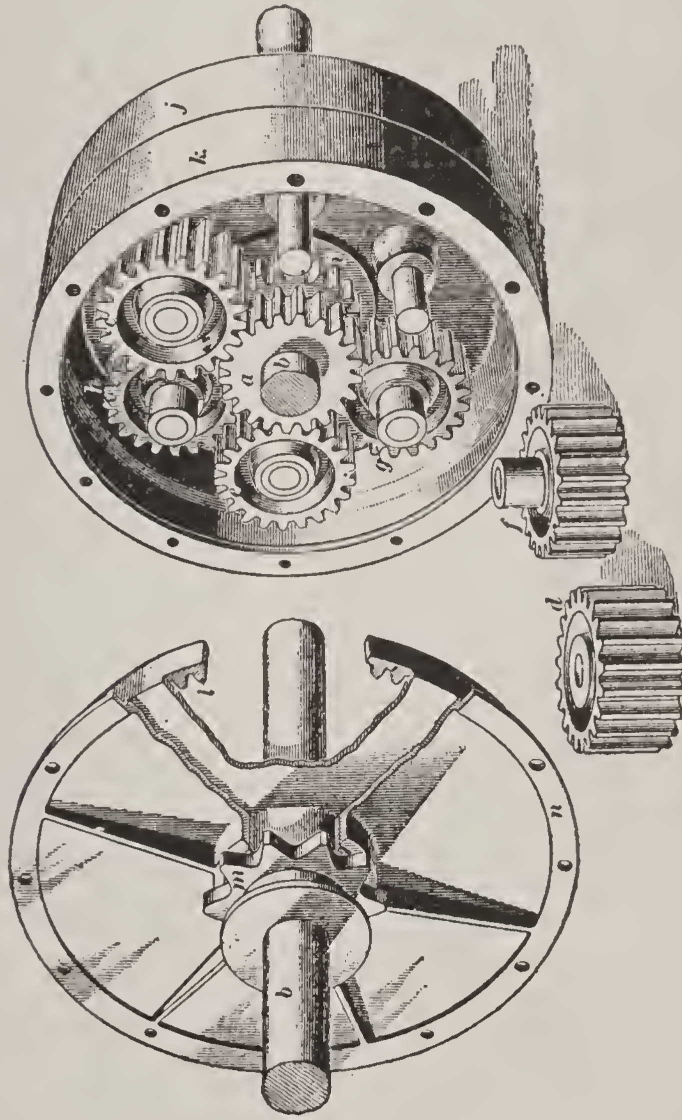


Fig. 97
Planetary Gear

the engine shaft b. The gears c, d and e all mesh with the gear a, and are made long enough to extend beyond a and mesh with the gears f, g and h in pairs. The last three gears in turn extend beyond the gears c, d and e, and

mesh with the gear i, which is keyed to a sleeve connected to the drum j. The gears c, d, e, f, g and h turn on pins fastened to the drum k, but only the gears c, d and e mesh with a, and only f, g and h mesh with the gear i which turns loosely on the shaft b. The internal gear l meshes only with the gears c, d and e, and is rigidly connected to the sprocket m that drives the automobile. The cover n is attached to the face of the drum k by means of screws, thus forming an oil reservoir that keeps the gears well lubricated when the automobile is running. There are separate brake bands around the drums j and k, and a friction disc keyed to the shaft just outside of the drum j.

When the friction disc is pressed against the drum j, the gear is held so that it must turn with the shaft; consequently, the entire mechanism is locked together and the sprocket m turns at its highest forward speed. If now the friction disc is released and the brake band around the drum j is applied so as to hold it from turning, then the gear a turns the gears c, d and e, causing them to turn the gears f, g and h; but, as the gear i is held stationary with the drum j, the gears f, g and h, and also the drum k, to which they are attached, must revolve around the gear i in the same direction as the shaft turns, but more slowly. The gears c, d and e turn on pins that are fastened to the drum k; consequently, they revolve with it as they turn on their axes and thus cause the in-

ternal gear l and the sprocket m to turn in the same direction as the shaft. This gives the slow forward speed.

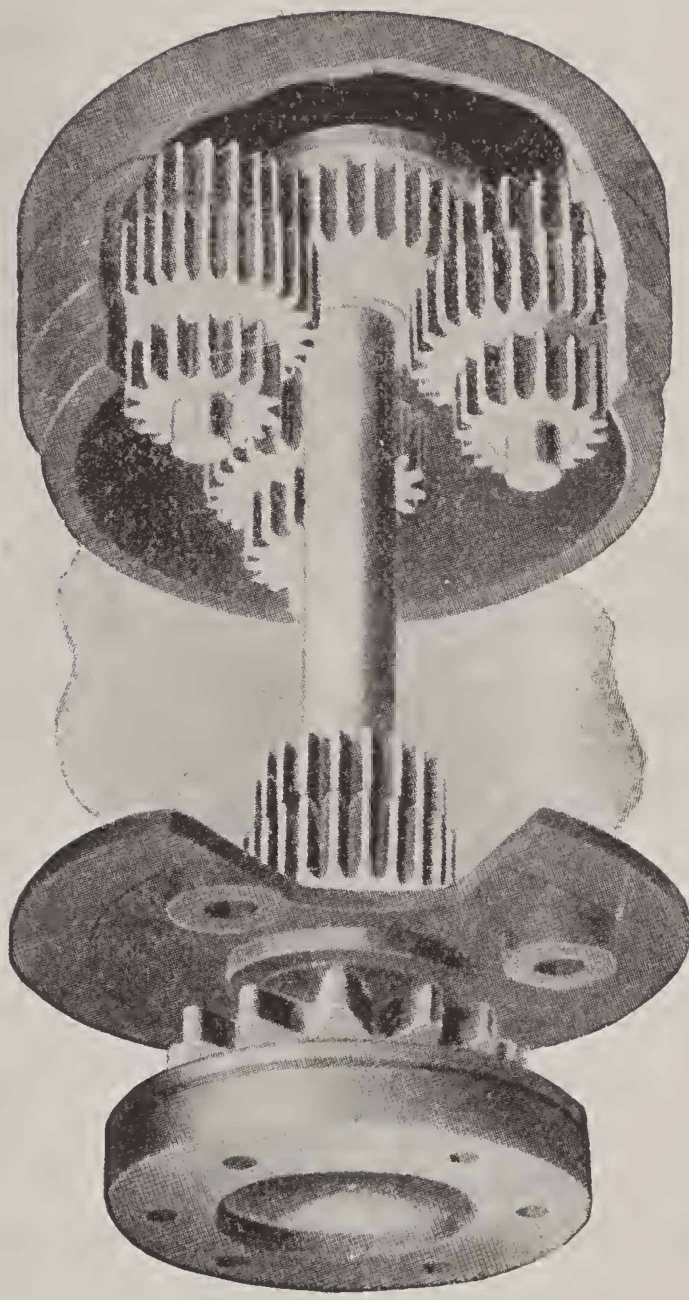


Fig. 97a
Planetary Transmission Gear with Case Opened

When the drum j is released, and the drum k is held by a brake band, the gears c, d and e are caused to turn on their pins, and consequently drive the internal gear l in a direction

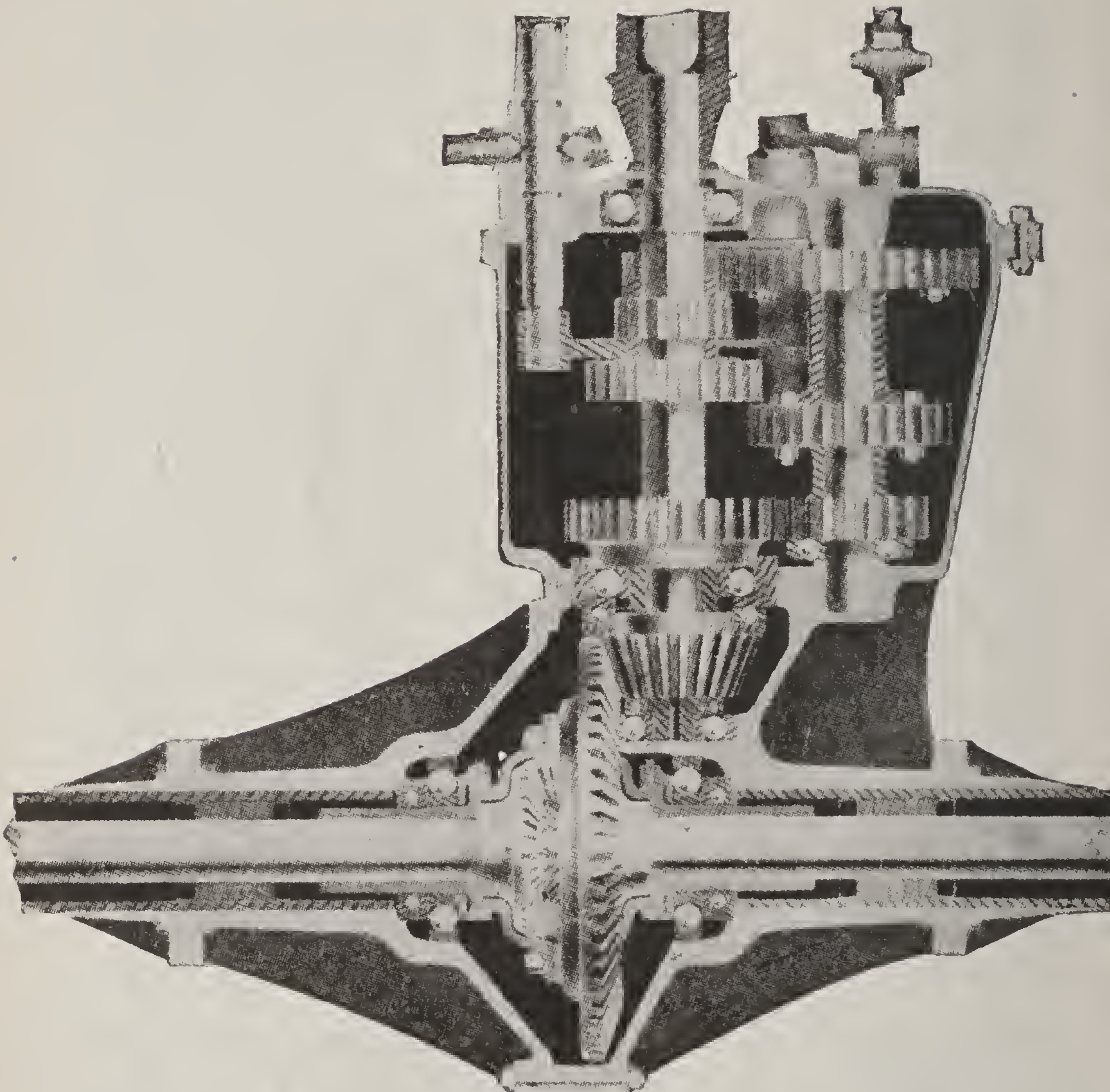


Fig. 97b
Combination Transmission and Differential Gear

opposite to that of the engine shaft, driving the automobile backwards. When the brake bands and friction disc are all free from the drums, the gears turn idly, and if the engine is running, no motion is transmitted to the sprocket and the automobile stands still.

Chassis. The word chassis since its adoption into the English language, is taken to mean the frame, springs, wheels, transmission and in fact

all mechanism except the automobile body. In its original French it does not mean all this, but is strictly restricted to mean the frame, or the frame and springs.

Chauffeur. This term when literally translated means the stoker or fireman of a boiler. The use of the word has been extended to the operator of a motor car, but does not usually refer to the paid driver, who is generally known as the mechanician or mechanic.

Circuit-breaker. A circuit breaker is a device consisting of either a solenoid, or an electromagnet which acts automatically to break the circuit of a storage battery charging plant, when a condition of either too low, or too high voltage exists.

Circulating Pump. The circulating pump is used in the belief that it affords a means for regulating the temperature of the jacket water supply, which would not always be the case with a thermal-syphon system. Such is not the case, as the pump, being driven direct from the motor, operates at a speed which varies with the motor speed. On starting the motor, it pumps cold water into the jacket. It pumps slowly at slow speeds, although the motor may be taking a full charge and heating rapidly. It pumps fast at high speeds, although the wind pressure and its consequent cooling effect may be very great. If a circulating pump could be used in connection with a device to control the

regulation of the motor temperature, the results would be more satisfactory.

Rotary pumps used in the water circulating system of gasoline automobile motors are of two forms, centrifugal and positive, or force-feed. A positive or force-feed rotary pump is shown in Figure 98. An annular ring around the pump shaft carries two blades, one of which is hinged to, and the other attached directly to

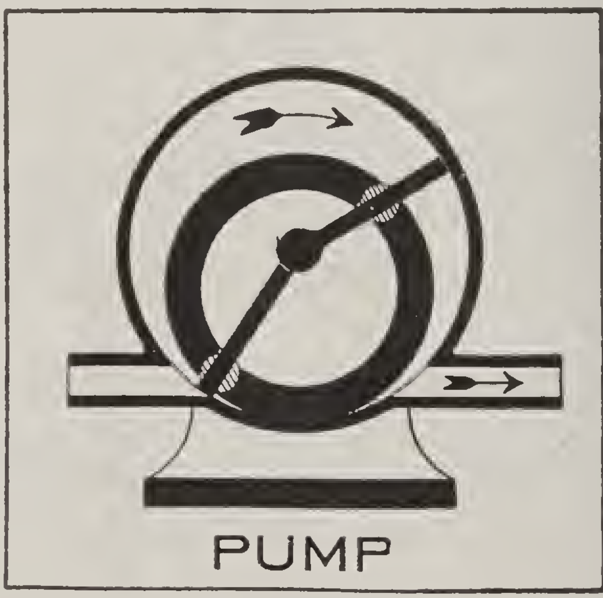


Fig. 98

the pump shaft. The outer ends of the blades are supported in the periphery of the annular ring, and rotate eccentrically with it. The pump shaft is concentric with the pump chamber, but the annular ring is located eccentrically around the shaft, which drives it by means of the fixed blade on the shaft.

Figure 99 illustrates another form of positive-feed rotary pump, in which the pump shaft is eccentrically located in the pump chamber.

A short cylinder which forms a part or portion of the pump shaft, carries two blades in a slotted opening parallel to, and coincident with the axis of the pump shaft. These blades are kept in contact with the interior periphery of the pump chamber by means of coil springs, located between the blades as shown. Rotation of the cylinder in the pump chamber causes a sliding or reciprocating action of the blades, due to

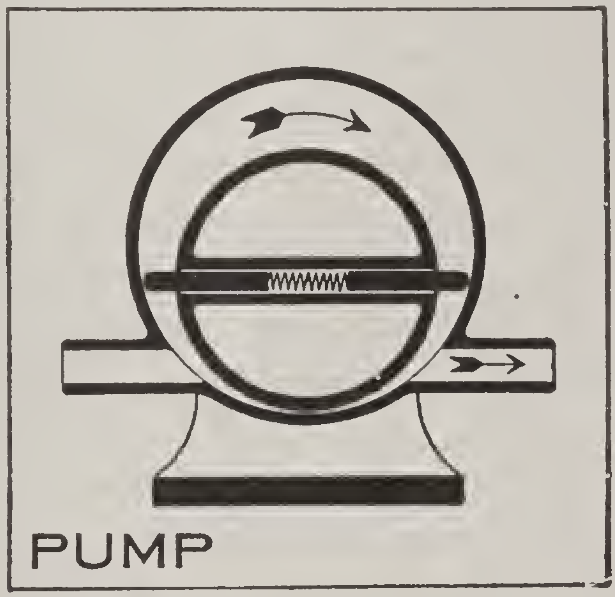


Fig. 99

the pressure of the coil springs between their inner ends.

Cleaning Car Body. In using soap for cleaning, the method adopted should be one that will preclude the possibility of getting raw soap on the paint and varnish, and also to prevent waste of soap. The soap should be thoroughly dissolved in water before using. In order to do this proceed as follows: Dissolve one pound of high grade soft oil soap to each gallon of water,

and use from a half to a full pint of this solution to each pail of wash water, just enough in fact to form a good suds. Another formula is: dissolve from 5 to 6 lbs. in a 50 gallon barrel, and fill the barrel full of water; then dip this solution out in a pail for washing. Do not put raw soap into the pail which is used for washing the car. Wet the car first with clean water, then wash with the suds, and immediately rinse with hose or sponge and clean water. After the car is dry, rub with soft cloth or chamois to bring up a high polish.

Clutch. Clutches may be classified as follows: a, cone; b, disc; c, band; cone clutches may, in turn, be subdivided as follows: a, metal to metal; b, leather faced; c, cork insert; while disc type may be classed as: a, leather faced; b, multiple disc; c, cork insert; and band clutches may be put down as of the a, constricting, b, spiral, or c, expanding types. Clutches, of whatever type or class, have but one prime object, i.e., to enable the operator to start and stop the car without having to stop the motor. There is a secondary consideration, if we take into account the fact that it is convenient to be able to slip the clutch, on occasion. Some types lend themselves to this secondary purpose with greater facility than others, and it is also true that some clutches are most easy of application, all things considered.

As clutches are at present designed, the question is, can slipping be tolerated? or, can

clutches be slipped to control the speed of a car? It is believed not. The average clutch has very little of the character of the average braking system, and when it comes to brakes they do not last so long that it is desirable to wear them out sooner than they will naturally need replacement. In other words, it seems quite out of the question to consider the clutches of today as suitable for the double purpose of clutching and speed controlling, by way of slipping the clutch at will. It is not uncommon to hear autoists talking of the multiple disc clutch as one that undergoes little or no deterioration as a result of continuous slipping under variations of load.

They seem to think that the large surface exposed, especially in view of the fact that the discs are submerged in oil, will prevent damage if the clutch is caused to slip. They forget that the discs are thin, and also that they are loose on the splines, keys, or feathers that prevent the discs from rotating. No member keyed onto a shaft will stand much abuse. This is especially so, if the member has but little bearing surface on the key. Even a considerable number of such members working in unison will fail to stand up under the work because the joint is not firm. Lost motion is bound to result in more lost motion in a short while, and in a multiple disc clutch the discs soon fray out and interfere with each other, and with the clutching functions, within a space of time so

short as to surprise even those most experienced in the use of this type.

BAND CLUTCH. A band, or friction ring, clutch, is shown in Fig. 100. The wheel which is connected to one of the shafts is shown at a, and the band, or ring which is connected to the other shaft and which is made in two parts, is shown at b and c. At d and e are curved arms

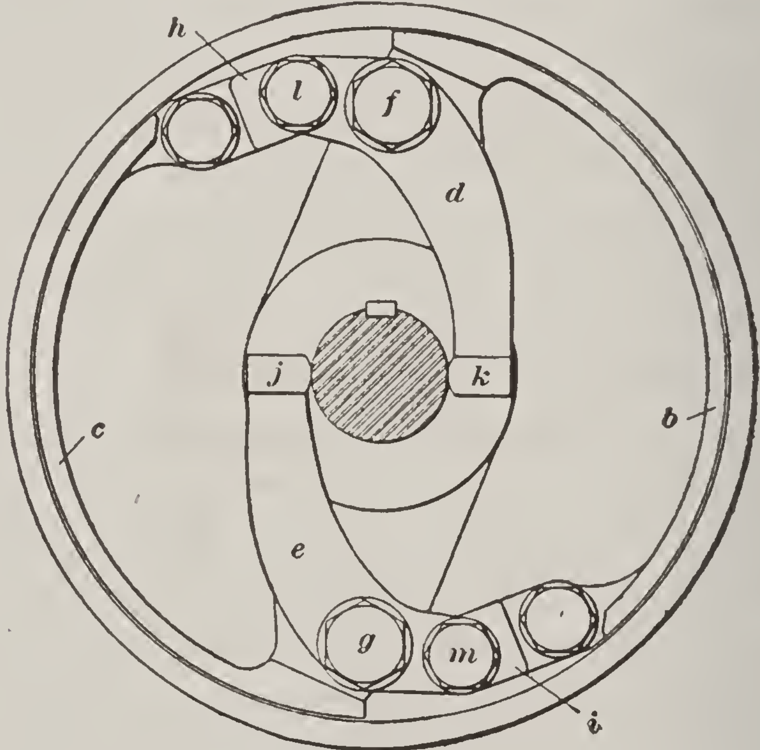


Fig. 100

pivoted at f and g. The links h and i connect these curved arms to the parts b and c of the band. By means of a fork, and tapered sleeve, not shown, the ends j and k of the arms are forced apart when the clutch is brought into use. This throws toward the shaft the ends l and m of the levers d and e, and brings the two parts b and c of the clutch ring in contact with

the friction or driving surface of the wheel a, which is thereby forced to turn with the driving shaft. The band clutch has had many exponents in the motor car art, but is open to centrifugal effects to such an extent that it requires considerable ingenuity to overcome troubles arising therefrom. At high engine speeds the operating levers have been so arranged as to lower the normal expanding pressure.

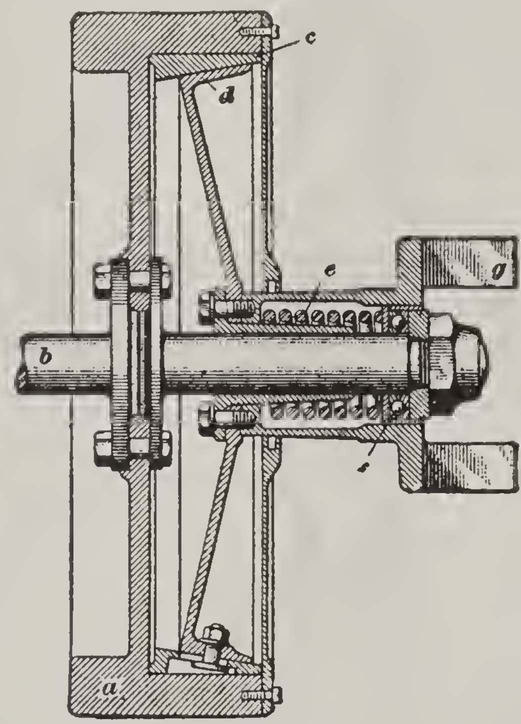


Fig. 101

Cone Clutch. There are a number of modifications of this type of clutch, the general principles of which are illustrated in Fig. 101. The flywheel a is secured to the shaft b by means of bolts through the web of the wheel. At c is an expansion ring into which the friction cone d fits. The helical spring e holds the cone against the expansion ring with the required

amount of force. At f is a ball bearing that takes the end thrust when the cone is pulled away from the expansion ring.

The arms g are coupled to the shaft that turns with the friction cone. Ordinarily the two parts of the clutch are held together by the pressure of the spring, and when it is desired to disconnect the cone, a foot pedal is forced down so as to act on a fork and sleeve and pull the cone

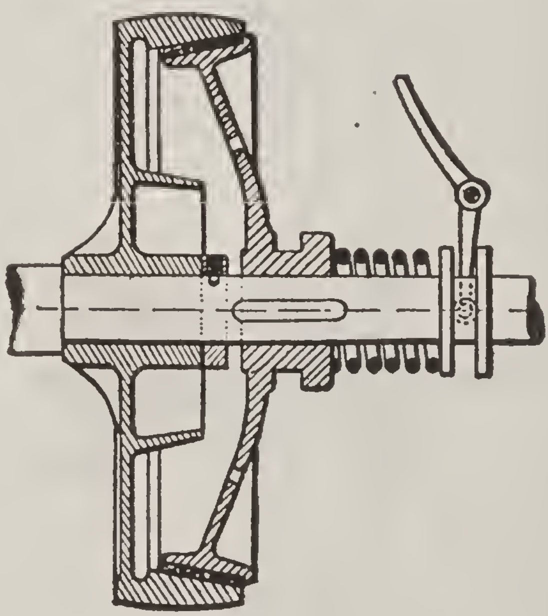


Fig. 102

away from the expansion ring. When the pedal is released, spring e forces the clutch into action again.

Fig. 102 is a sectional view of a form of leather faced cone clutch in which the male part of the cone moves axially toward the engine. Fig. 103 shows a clutch constructed on the same principle, but in place of having one strong actuating spring surrounding the axis, it has three weaker spiral springs near the pe-

riphery of the male member. Fig. 104 is a vertical section of a clutch suitable for a 50 H. P. car. The cone angle is 13 degrees, and the diameter 16 inches, with a total frictional area of 128 square inches, the axial pressure resulting from the spring being 375 lbs. A small spiral plunger spring A under the leather face B causes it to pick up the load more quietly and smoothly. Fig. 105 illustrates an early form of clutch intended for a car of about 20 H. P. One form of toggle joint is also shown at A.

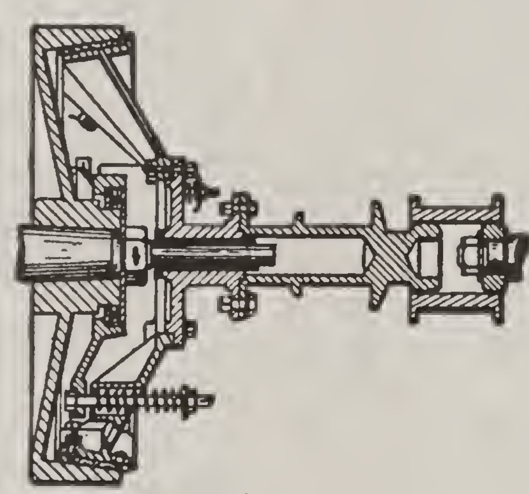


Fig. 103

This clutch also has multi-springs for creating the proper frictional contact, and a peculiar form of spring application simple in the extreme. A multi-cone clutch is shown in section in Fig. 106. Its action is as follows: When the clutch engages, the smallest cone seizes first, commences to revolve and subjects the spiral springs between the next two clutches to torsional movement, which draws them together and brings the two outer cones into action; the idea being that the small clutch shall slip, tend

to accelerate the car, that the medium clutch shall behave in a similar manner and that when the large clutch comes into play the three combined pick up the load and move the car.

The so-called inverted cone is well illustrated

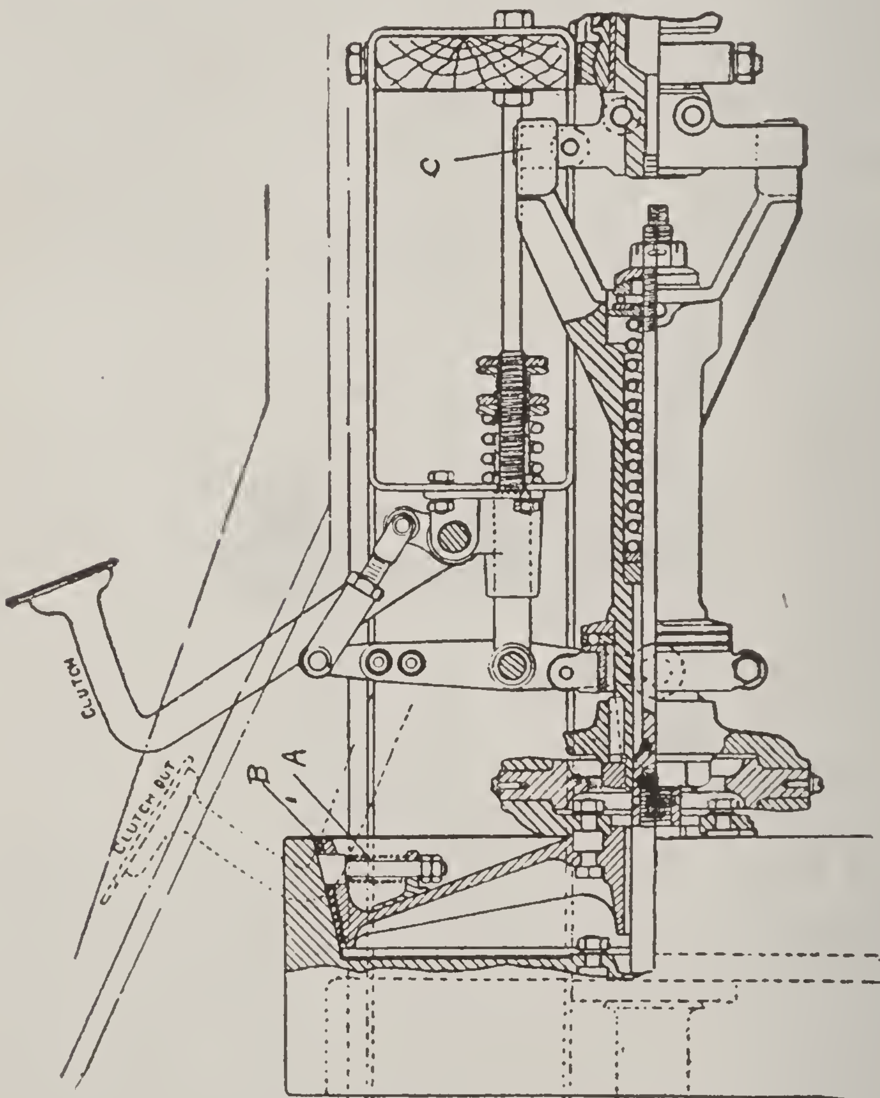


Fig. 104

in figure 107. The reversed cone is contained in an extension A, built onto the flywheel B. When the cone is disengaged it moves toward the engine, exactly reversing the action of the foregoing type. This clutch has its adherents,

and it is a good one, differing very slightly, if properly assembled, in its efficiency from the direct-acting cone. It may be kept free from dirt and oil much more perfectly than in the other form.

Disk Clutch. A clutch of the multiple-disc type is shown in Fig. 108. A two-arm spider a, keyed to the shaft b, serves to hold in place a number of metal discs c, between which are other metal plates d held on the sleeve e by means of a key f. The sleeve e is in turn keyed

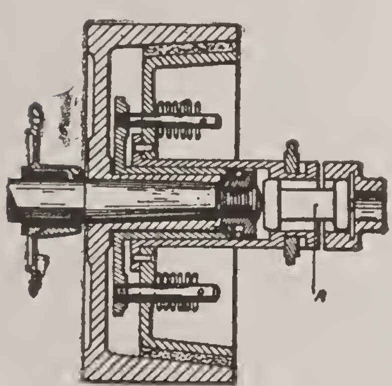


Fig. 105

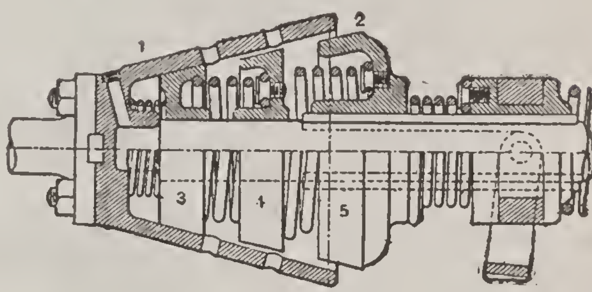


Fig. 106

to the shaft g, and to it is screwed a ring h having three pairs of lugs carrying three levers i, with rollers j at their outer ends, as shown. The other ends of the three levers press against the plate k when the clutch is engaged by an inward movement of the collar l, plate k being free to move along the key f. Discs c are free to move longitudinally on the arms of the spider a, and also on sleeve e, around which they rotate when the clutch is out of engagement; but the arms of the spider, fitting into slots in the discs, cause them to rotate with the shaft b.

The plates d are free to move longitudinally on the key f in the sleeve e; and since the sleeve is keyed to the shaft g, it is evident that, when in engagement with the discs c, the plates d must cause the shaft g to turn with the shaft b. The discs c and plates d run in an oil bath,

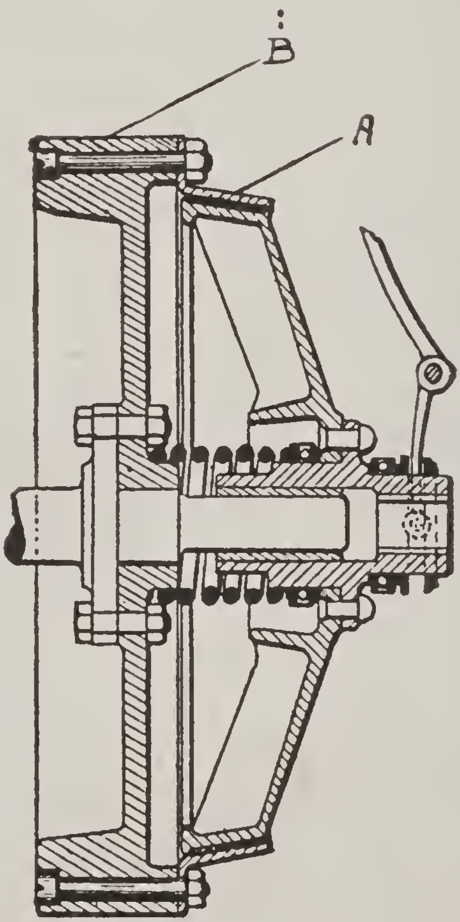


Fig. 107

obviating wear of the plates and discs. These are brought together forcibly by throwing the cone faced end of the collar l against the rollers j, thereby causing the ends of the three levers i to press the plates and discs together with sufficient force to cause the shafts b and g to rotate as one shaft.

Horse Power of Clutches. A simple formula for calculating the ordinary cone clutch is the following, by Charles H. Schabinger:

$$\text{H. P.} = \frac{\text{P f r R}}{63{,}000 \sin \text{O}}$$

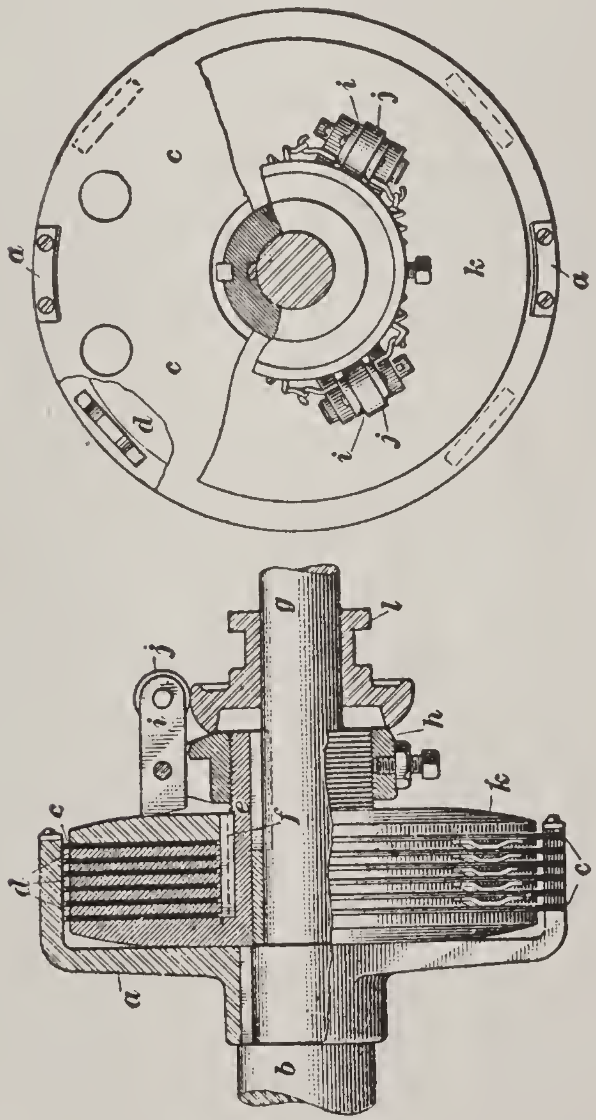


Fig. 108

P = Assumed pressure of engaging spring in pounds;

f = Coefficient of friction, which in ordinary practice is about 0.25;

r = Mean radius of the cone in inches;
R = Revolutions of the motor per minute;
sin O = Sine of the angle of the clutch.

To obtain the size of spring when the horse-power is known, the following formula may be used with good results:

$$P = \frac{h.\ p.\ 63{,}000 \sin O}{f\ r\ R}$$

the same symbols being used as in the preceding formula. It will be noted that the coefficient of friction used is 0.25. This is probably near enough for a properly lubricated leather-iron clutch.

Clutch Troubles. One of the greatest sources of trouble for the novice lies in the clutch. This may be just right, it may be slipping, or it may be what is called fierce. The second manifests itself in such pleasant situations as climbing a hill when, with the engine running at its highest speed and the proper gear engaged, the car starts to run backward instead of forward. Or on the level, with the engine racing and the high gear in, no speed results.

The last condition shows itself in the sudden jumping forward of the car when the clutch has been let in, or it may even be so severe as to shear off the bevel driving gear when used with studded non-skid tires or any form that will not slip easily.

To repair the first, look at the leather, if this

is all in good shape with an apparently good surface, but has lubricating oil on it, wash the surface well with gasoline. It is not a bad idea to roughen the surface of the leather a little with a coarse file.

The harsh or fierce clutch is remedied by the application of a proper oil for this purpose. Castor oil is universally used and a good way is to soak the complete clutch in it over night. This will cure a case of harsh leather, but it may be that the trouble is only a lack of adjustment of spring tension. Usually there is an adjusting nut and a locking nut. Back off the latter and make an adjustment. Then tighten the lock nut to retain it. For the beginner, it is better to adjust a little at a time and make several successive jobs of it than to try to do it all at once. But always adjust it as soon as possible.

The leather of the ordinary cone clutch by degrees acquires a sort of coarse surface glaze, which may or may not represent actual charring of the leather, but is certainly due to the slipping it experiences. A leather with its surface so glazed has a very harsh action, since the surface is so hard that it grips all at once. The glazed surface will not absorb oil to any appreciable extent, a fact which is easily seen on attempting to dent the surface with a thumb nail after giving the oil time to soak in. In this condition the best thing to do is to put on a new leather. Unless the angle of the cone is too

abrupt, a piece of ordinary belting will serve the purpose, provided it is of uniform thickness throughout. The belting may be soaked in neatsfoot oil over night before applying, and this will render it pliable enough to take the shape of the cone. If the old leather is retained in service it becomes almost essential to squirt a little oil on it every day or two, as otherwise it may take hold with such a jerk as to endanger the transmission shafts. If the cone releases by drawing backward, there are probably openings in the web of the cone through which the spout of a squirt can may enter. Oil squirted into the flywheel interior will then quickly find its way to the clutch surface. Sooner or later, however, the leather will become glazed so smooth that it will not hold at all, and it is then liable to slip and burn up without warning. There are few things more exasperating than a clutch which cannot be made to hold properly, particularly when the car happens to be covering a bad stretch on which every available bit of power that can be transmitted to the rear wheels is necessary. The use of emergency remedies under such circumstances most often leads to the necessity for clutch repairs, as road dirt and grit are not the best things possible for the leather facing, and frequently no other friction producing compound is to be had at the time.

Renewal of Leather on Cone Clutch. Remove the old leather by cutting off the rivets

on the underside, and driving the rivets through to the outside. Keep the old leather and use it as a pattern by which to cut the new piece. It will be much better, however, to purchase from the factory a new leather of the proper width and thickness. As a new leather will have considerable "give," it must be stretched tightly over the cone. First cut one end of the leather square and fasten it to the cone with two rivets. The other end should not be cut at this stage of the work, but brought around to meet the fastened end, and, after tightly stretching it over the small end of the cone, fasten it with a single rivet. Then force the leather up onto the cone, drill out and countersink the holes and rivet up securely. The only knack in the operation is to keep the leather tight that it may be a snug fit on the cone. A loose leather will, naturally, be a dead failure. After the leather has been forced into its place the uncut end should be trimmed to make a good joint. Any unevenness may be trued up with a file. The new leather will readily absorb several applications of castor oil before it becomes smooth and pliable.

Care should be taken that the rivet heads are countersunk below the surface of the leather. In case they work flush, owing to the wearing down of the leather face, they should be riveted. The "biting" or jerky action of a cone clutch may often be traced to the rivets working out, and this will frequently prevent the

clutch from being readily disengaged. Reriveting will prove an effective remedy in this case, and considerable additional service may be had from the leather before it wears down to the rivet heads.

Combustion Chamber. That part of an explosive motor in which the gases are compressed, and then fired, usually by an electric spark, is known as the combustion chamber. The interior of the combustion chamber should be as smooth as possible and kept free from soot, or hard carbon deposits such as are induced by excessive lubrication, or the use of too rich an explosive mixture.

It will be found to be no small task in designing an explosive motor with the usual form of valve construction and operation, to keep the combustion chamber down to the required dimensions and at the same time have it free from bends or contracted passages between the combustion space and the valve chamber.

Many attempts have been made to obviate this difficulty by making the combustion chamber simply a straight extension, or continuation of the cylinder. In this manner both the admission and exhaust-valves can be placed in the cylinder itself and an ideal combustion space secured. This plan has, however, certain disadvantages, from the fact that it not only lengthens the motor, but requires a more complicated form of valve operating mechanism

than if the valve chamber were at the side of the cylinder as is usual.

Combustion Chamber, Dimensions of. If it is desired to ascertain the cubic contents or dimensions of the combustion chamber of an existing motor, they may be found by filling the combustion space with water, then obtaining the weight of the water in ounces, which multiplied by 1.72 will give the capacity of the chamber in cubic inches. If a motor is to be designed with a given bore and stroke, the first thing to do is to decide on the amount of clearance or combustion space at the end of the cylinder for the gases to occupy after compression.

If the combustion space could be made as a continuation or extension of the cylinder bore, it would be an easy matter to determine the required clearance, as it would simply be some fraction of the total piston stroke.

But as the general design of a combustion chamber deviates widely from a plain section or length of a cylinder as above described, being in some cases flat, oval, elliptical, semi-spherical and even rectangular in cross section, some other method must be used to calculate the required clearance.

To do this correctly the contents of the combustion chamber in cubic inches must first be ascertained, and then apportioned between the valve chamber or chambers and the clearance proper which lies directly behind the piston head.

To find the cubic contents of a combustion chamber when the degree of ocmpression in atmospheres is known: Let S be the stroke of the piston in inches and A the area of the cylinder in square inches. If N be the number of atmospheres compression and C the required contents of the combustion chamber in cubic inches, then

$$C = \frac{S \times A}{N - 1}$$

Example: Find the cubic contents of the combustion chamber for a motor of 4-inch bore and 5-inch stroke with 4 atmospheres compression.

Answer: Five multiplied by 12.56 equals 62.83, which divided by 3 gives 20.94 as the number of cubic inches required.

Commutators, Care of. Commutators with a make and break form of contact-maker, should have the platinum contacts cleaned at least once a week, with a small piece of fine sandpaper.

Commutators having a rotary wiping form of contact, should have the brass or copper segment thoroughly cleaned in the manner just described, and all grease or dirt removed from the fiber portion of the commutator.

All thumb or lock-nuts and adjusting screws should be carefully gone over, and the condition of the wiring from the battery and coils examined very closely. Ten minutes spent in this

manner once a week may save long delays and much laborious work at some future time.

Commutators, Forms of. The commutator of the ignition system of a multi-cylinder gasoline motor has a three-fold use: To switch the battery current in and out of the electrical circuit at the proper time—To transfer the battery current successively from one coil to another—To vary the point or time of ignition of the explosive charge in the motor cylinder.

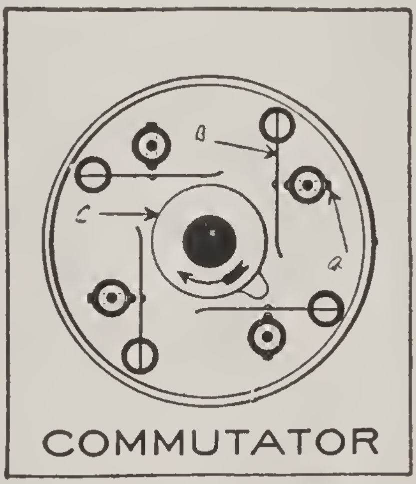


Fig. 109

The commutator shown in Figure 109 is for a four-cylinder motor and is designed for use with induction coils without vibrators, which are known as single-jump spark coils. The studs of the screws A and springs B are carried by insulated bushings located in the back of the commutator case. The nose of the cam C successively engages with the springs, causing them in turn to make contact with their respective screws. The battery and coil circuit is completed through the screws A, and a

ground to the cam C, by means of the springs B, when in contact with their respective screws and the cam.

This device is said to cause a good spark at the plug on account of the quick break between the spring and the screw, the electrical circuit being broken the instant the spring leaves the screw and before the cam has allowed the spring to resume its normal position. This form of commutator cannot be short-circuted by oil

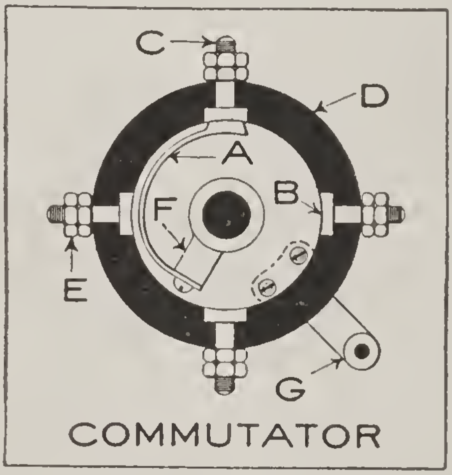


Fig. 110

or dirt getting between the spring and the screw, as the spring B only forms a part of the electrical circuit when in contact with both the cam C and the screw A.

Another form of commutator for a four-cylinder motor is illustrated in Figure 110, which has a rotary spring contact-maker A, which engages successively with the heads B of the screws C. The screws are spaced equidistant around the fiber ring D, which also forms the case of the commutator, and are held in position

by the locknuts E. The spring contact-maker A is attached to a hub F on the cam shaft of the motor. The time or point of ignition may be varied by moving the commutator case about its axis by means of a rod attached to the arm G.

Figure 111 shows two commutators of very similar construction. The one at the left in the drawing is for a two-cylinder motor, and has flat spring-steel contact-makers. The commu-

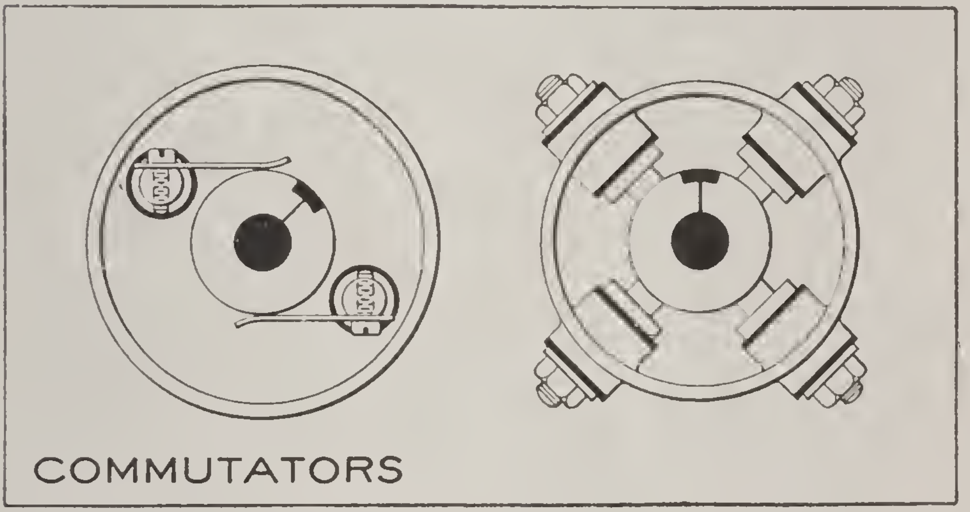


Fig. 111

tator shown at the right of the drawing is for a four-cylinder motor and instead of having flat spring contact-makers, it has either carbon or copper contact-brushes, which are held against the commutator by short coil springs in the insulated bushings located around the periphery of the commutator case. The commutator is made of vulcanized fiber with a short brass or or copper segment, which is grounded to the cam shaft as shown.

The forms of commutators illustrated in the drawings may be constructed for use with a motor of any number of cylinders, by increasing or decreasing the number of contact-makers located around the commutator.

Compensating Joints. On account of the distortion of the frame or running gear of an

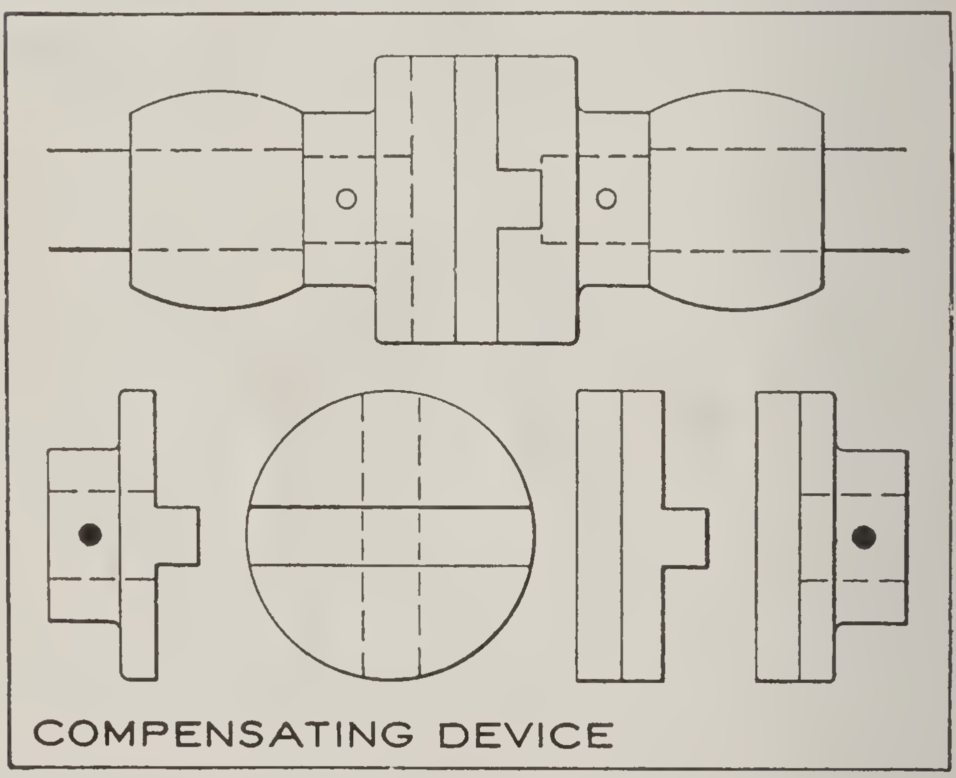


Fig. 112

automobile, due to unequal spring deflection and irregularities of the road surface, means should be provided to insure flexible joints or connections between the various rotating parts of the mechanism of a car. The device shown in Figure 112 is not susceptible to any great amount of angular distortion, but will transmit power with a practically uniform velocity, with

the axes of the shafts considerably out of alignment in vertical or horizontal parallel planes.

The form of compensating joint shown in Figure 113 may be operated with the axes of the shafts at an angle to each other, or with the shafts out of alignment with each other in vertical or horizontal parallel planes, and has quite a range of operation with either condition. Both

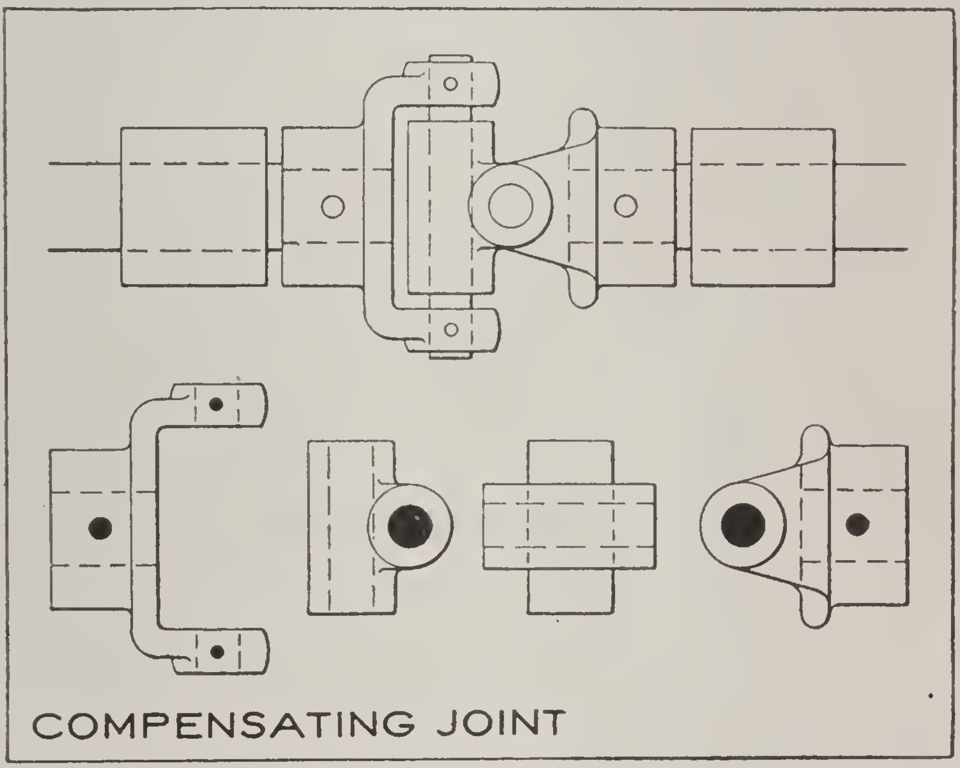


Fig. 113

forms of the device require to have bearings on either side, as shown, to insure their proper working.

Compression. Normal compression in any given design of motor would be the compression (cold) fixed by the designer by the relation of the sweep of the piston to the clearance space. Normal compression is not the same, as

measured in pounds per square inch, in all motors. The normal compression as against loss of compression would be evident to a motorist in the act of cranking. Were the compression to become abnormal, as a result of carbon deposit, it would be rendered manifest by knocking on a gradient, or by way of pre-ignition.

The cold compression can be found by means of a gauge reading to about 90 pounds per square inch. Screw the gauge into the threaded hole, normally used for the spark plug. Another way is to use a spring balance, hooked to the starting crank, and by a steady up pull, against the compression, the pull in pounds resultant of the compression may be noted.

Allowable Compression. Assuming that the design is good and that a motor is in proper working order, the allowable compression depends upon several factors as follows:

(1) If liquid gasoline is entrained, upon the latent heat of evaporation of the liquid, of which gasoline is composed considering its complex character.

(2) The specific heat of the mixture, which will differ as the composition changes, it being the case that all the contents entering into mixtures are not of the same specific heat.

(3) The extent of scavenging, and the heat of the spent products of combustion, in the absence of complete scavenging.

(4) The temperature of the water in the water-jacket, or the efficiency of the air-cooling

process, if air is used direct for purposes of cooling.

(5) The design of the cylinders, and the extent to which the surfaces maintain an even temperature; if some one zone on the surfaces is at a high heat, pre-ignition will follow, it being the case that this heated zone will be at the bottom of the trouble, nor does it matter if the zone is of small area. This trouble is most likely in cylinders of relatively large bore, in which the piston is likely to heat up at the axis of the head, which is the greatest distance away from the cooling medium, and it generally is the part in which the heat conductivity is a minimum because the metal is coated with a crust, due to elevated temperature, and the metal in the head is thin in order to have the piston as light as possible.

(6) If the valves are not properly water-jacketed they are likely to heat above the desired temperature, and pre-ignition will be due to such over-heat.

(7) In some cases to make the motor as short as possible the water-jacket is so designed that but little of the cooling liquid will circulate over the dome of the combustion chamber, which is just the part that requires the greatest amount of cooling, and pre-ignition will be eminent in all such cases.

(8) Fins, seams, protuberances, etc., due to defective designing, or misplaced cores in the

foundry process, will heat up and they will be the direct cause of pre-ignition.

(9) If the water ciculation is not good, or if the amount of water circulated is inadequate, pre-ignition will follow. In some cases the water is enabled to short-circuit across from the inlet to the outlet without passing over the hot surfaces, and this a prolific cause of pre-ignition.

(10) Increasing compression tends to increase the terminal pressure, thus allowing and engendering an increase in speed of the motor without pre-ignition because the conditions of scavenging improve as a result.

(11) Running on a "retarded" spark results in over-heating, and pre-ignition is likely to follow if the other (remaining) conditions are favorable.

(12) Running on a mixture that is too rich will cause excess heating, which is indicated by a steaming cooler, and pre-ignition is likely to be one of the manifestations.

Although the compression of the charge during the second stroke requires the abstraction of considerable power from the fly wheel, the work done upon the charge in compressing it is more than returned, during the power stroke. It is therefore found that with a high degree of compression, a high fuel economy is obtained, and a large output is secured from a motor of relatively small size.

Much of the increased power for equal cylin-

der capacity is due to compression of the charge, because the most powerful explosion of gases takes place when the particles are in closest contact.

Another advantage of a high compression motor is that on account of the smaller clearance, less cooling water is required than with a low compression, as the temperature, and consequently the pressure, falls more rapidly. The loss of heat through the water jacket is thus less in a high compression than in a low compression motor.

The difficulty about obtaining high compression is that if the pressure is too high, the charge is likely to ignite prematurely, as compression always results in increased temperature.

LIMITS OF COMPRESSION. With gasoline vapor and air, the compression cannot be raised much above 85 pounds per square inch, but with the heavier fuels, such as kerosene, a compression as high as 250 pounds per square inch has been used economically. It has been the advantages of high compression that has turned the designer of automobiles toward the heavier fuels; but, with the increase of compression, there are many troubles in regard to loss of power and increased fuel consumption, owing to the wear of the valves, pistons and cylinders, which produces a loss in compression and explosive pressure, and a waste of fuel by leakage.

COMPRESSION, HOW TO CALCULATE. The com-

pression in atmospheres of a motor may be readily found by dividing the cubic contents of the piston displacement by the cubic contents of the combustion chamber in cubic inches, and then adding one to the result.

To ascertain the compression in atmospheres of a motor, when the cubic contents of the combustion chamber are known: Let S be the stroke of the piston in inches and A the area of the cylinder in square inches. If C be the contents of the combustion chamber in cubic inches and N the required compression in atmospheres, then

$$N = \frac{S \times A}{C} + 1$$

Example: Find the compression in atmospheres of a motor of 4-inch bore and 6-inch stroke, whose combustion chamber has a capacity of 18 cubic inches.

Answer: Six multiplied by 12.56 equals 75.36, which divided by 18 gives 4.19, and 4.19 plus 1 equals 5.19, or the compression in atmospheres required. One atmosphere = 14.75.

If it is desired to ascertain the compression in atmospheres of a motor, the combustion chamber of which is of such shape that its dimensions cannot be accurately calculated, its cubic contents may be found by filling the combustion chamber with water, and after removing the water, ascertaining its weight in ounces,

and then multiplying the result by 1.72. This gives the capacity of the combustion chamber in cubic inches. The compression of the motor can then be readily calculated from the formula given herewith.

Compression, How to Test for Leaks in. To discover if there are any leaks in the compression of a gasoline motor, a small pressure gauge reading up to 75 pounds should be fitted into the spark plug opening in the combustion chamber by means of a reducing bushing. When turning the starting crank of the motor slowly the gauge should indicate at least 60 pounds per square inch if the compression is in good condition.

To test for leaks, fill a small oil can with soapy water and squirt round every joint where there may be a possible chance for leakage. Get an assistant to turn the crank and watch for bubbles at the joints.

If the joints are all tight, next examine the condition of the admission and exhaust-valves and if either of them needs regrinding, it should be done, first with fine emery powder and oil, then finished with tripoli and water.

When the valves have been ground to a perfect fit, if the compression still leaks, the piston rings should be examined, as the trouble will be found to be with them.

Condenser, Use of. A condenser is used in connection with a Rumkorff, or jump-spark form of induction coil to take up or absorb the

static charge of electricity, occasioned by the self-induction, or electrical reaction in the primary winding of the coil upon the breaking of the battery circuit by the interrupter or vibrator. This static charge is given up or dis-

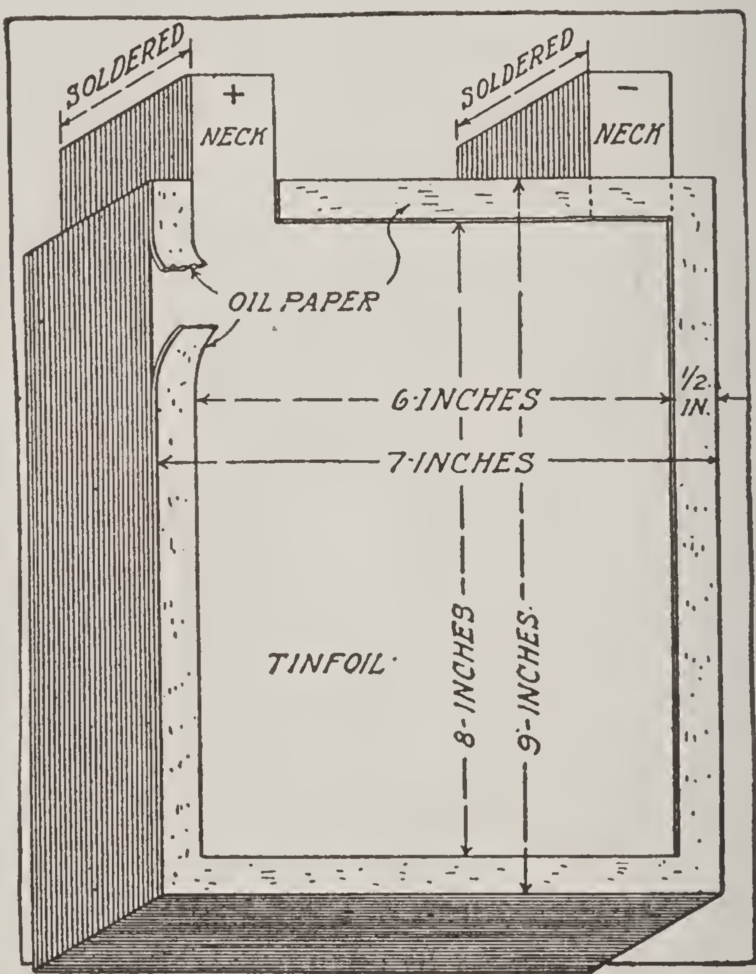


Fig. 114
Condenser

charged into the primary winding of the coil along with the battery current upon the closing of the circuit, thus intensifying the action of the secondary winding of the coil in a great degree.

By absorbing the static charge of electricity

the condenser helps to decrease the spark or arc between the platinum contact points of the interrupter or vibrator, thereby lengthening the life of the platinum contacts by reducing the erosive action of the induced current spark. A jump-spark coil very often refuses to work properly on account of the condenser connections having become loose.

The capacity of a condenser is directly proportional to the area of the tinfoil sheets composing it, to the distance between the sheets, and to the inductive capacity of the dielectric, or separating medium.

In condenser work it is the custom to cut the tin-foil sheets to some convenient rectangular shape, as shown in Fig. 114, each one with a neck so that all the + sheets can be soldered together, on one side, and all the — sheets on the other. The dielectric paper is cut without necks, so that the necks of the tin-foil sheets can be readily contacted with each other, in such a way, however, that the + sheets will not contact with the — sheets at any point. The paper is 1 inch wider than the tin-foil, so that the paper extends out for ½ inch all around, and beyond the tin-foil. In the illustration the top sheet of paper is removed to show the shape of the tin-foil sheets, and it will be observed that all the tin-foil sheets are of the same size, but they are so turned that the + sheets have their necks all to one side, while the — sheets have all their necks to the other

side. Any number of sheets can be used, with the understanding that a sheet of oil-paper will be placed between adjacent tin-foil sheets, so that the + and — sheets will not contact with each other at any point.

If the paper is pierced, or if the + and — tin-foil sheets contact with each other, the condenser will fail to perform its functions, and it sometimes happens that the sheets are punctured in service, thus rendering the condenser

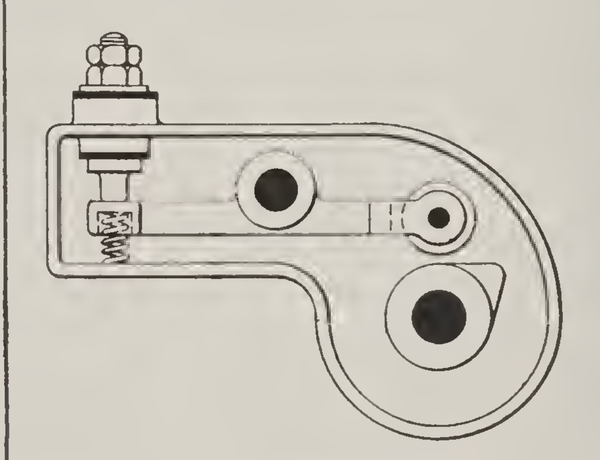

CONTACT BREAKER

Fig. 115

valueless for the intended purpose until the puncture is repaired, to do which requires that the fault be found, and a new sheet of paper substituted.

Constant Speed. One of the best lessons in the proper method of driving a car is that of driving at a constant speed, no matter what the road conditions. The autoist should previously determine a speed compatible with the nature of all roads over which the car is to pass, and

should see that the speedometer hand keeps at the determined speed throughout, regulating the spark and throttle and changing gears if necessary. Considerably more will be learned about the flexibility and power of the motor in driving in this way for a few times in numerous drives in the ordinary way.

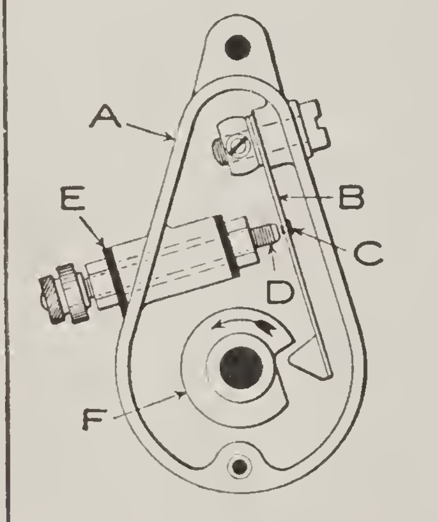
Contact-breaker. Some forms of high speed gasoline motors with an induction coil of the single-jump-spark type, have a device known as a contact-breaker to open or break the electric circuit of the battery and coil, at the proper time for the passage of the arc or spark at the points of the spark plug. On account of the extremely high speed of such motors, and to allow time for the magnetism or magnetic flux in the core of the coil to attain a density sufficient to produce a good spark at the plug points, it is found necessary to keep the battery and coil in a closed circuit, except during the brief interval necessary for the passage of the spark at the plug points.

Figure 115 illustrates one form of contact-breaker. The left-hand end of the double lever is kept in contact with the lower end of the insulated pin, by means of a short spring immediately below it. When the nose of the cam engages with the roller in the fork or jaw at the right-hand end of the double lever, instant separation of the nose of the insulated pin and the left-hand end of the double lever takes place, breaking the electric circuit and

causing a spark to occur at the points of the spark plug.

The electric circuit of the battery and coil is completed by one wire being connected with the lock-nuts on the upper end of the insulated pin and the other wire grounded on the case of the contact-breaker.

Contact-maker. One of the simplest methods of electric ignition for explosive motor use is



CONTACT MAKER

Fig. 116

that known as the single-jump-spark system, with which a plain induction coil without a vibrator or trembler is used. The secondary spark is produced by means of a mechanical device operated by the cam shaft of the motor. The devices illustrated, and which are known as contact-makers, cause a spark to arc or jump between the points of the spark plug in the combustion chamber of the motor.

Figure 116 shows one form of contact-maker. The case A is usually attached to the gear box of the motor. Attached to a boss on the inside and near the upper end of the case is the trembler B, consisting of a flat steel spring with a nose at its lower end. Near the center of the spring is a platinum contact-point C. On the opposite side of the case is a bushing with insulation E, carrying the screw D, which is so adjusted that it does not quite contact with the platinum point C of the trembler. As the cam F revolves in the direction indicated by the arrow, it comes in contact with the nose of the trembler B, and pushes the platinum point C still further away from the screw. Shortly before the cam has arrived at the position shown in the drawing, it has released the nose of the trembler, allowing it to fall; this action produces a vibrating effect, opening and closing the circuit repeatedly and with great rapidity, between the point C and screw D.

This is supposed to cause a stream or succession of sparks to occur between the plug points in the combustion chamber of the motor. In practice, however, and at a high rate of speed, only a single spark occurs.

Another form of contact-maker is shown in Figure 117. The trembler B has a small roller upon its lower end which at the proper time is engaged by the nose of the cam F. The screw D is carried in a metal block I, which is attached to the back of the case A by suitable

insulating bushings E. The screw H in the insulated bushing at G, makes the electrical connection from the coil and battery, through the block I and screw D, to the platinum contact C on the trembler B. The operation of this device is precisely the same as that of the one shown in Figure 116.

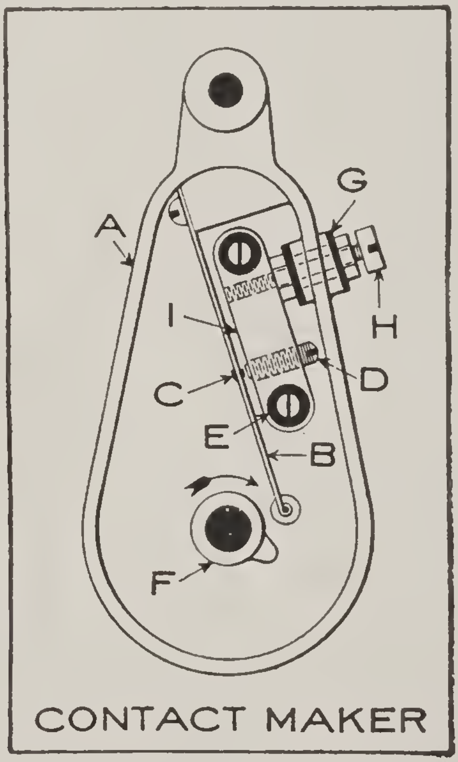


Fig. 117

Cooling Systems. The cooling of a gasoline, or other automobile engine may seem a simple thing to the uninitiated, but in reality it is far from that and it is a fact that the deeper one goes into it, the more complex the situation becomes.

The cooling of internal combustion engines in which category, automobile engines come, is

divided into two classes, viz., air cooled and liquid cooled. There are two reasons for cooling the cylinder walls. One is to permit of proper lubrication, and the other is to prevent pre-ignition. But it is advisable to allow the cylinder to work at as high a temperature as the lubricating oil will stand without carbonizing. The nearer the cylinder temperature can be kept to 350 degrees the more efficient will the motor be, speaking from the thermal standpoint, while on the other hand, mechanical efficiency may be sacrificed by too high temperatures. Therefore a balance between the two should be established, and this course is usually pursued in practice.

Cooling Solutions—For Winter. Radiators are costly, delicate and composite in construction, the latter due to the plurality of metals in their make-up, hence electrolytic action takes place, due to the difference of potential natural to the different metals immersed in a saline bath. Therefore great care should be exercised in the preparation of anti-freezing solutions made up of calcium chloride (common salt) and water. Any approach to the saturation limit is attended with danger of precipitation. The saturated solution is ascertained at 60 degrees F., and increasing the temperature increases the capacity of the water to hold the salts in suspension.

On the other hand, the Ohmic resistance of a solution is lowest at about half saturation.

To sum up, it is experience that counts, and it is still a question as to the extent to which saline solutions can be used with safety. Of course there is no solution as good as water alone, but unfortunately water will expand when it freezes, and it will freeze on small provocation in a radiator. Oil as a cooling medium has points in its favor which some authorities claim render it more efficient than water, as for instance it has a higher boiling point, about double that of water, and as a result the oil will not waste away except by leakage. The heat exchange occurs at a higher temperature, thereby increasing the efficiency of the motor. Then also the area of radiating surface may be smaller, with a conesquent decrease in weight, while the work of the fan is rendered of less importance. A light, thin, pure mineral oil is the most reliable. Animal, and vegetable oils are more apt to become rancid, the acid in them also attacks the metal of the radiator.

Alcohol, or a mixture of alcohol and glycerine, also are serviceable. With the former a temperature of 30° below zero, F., can be withstood, while the latter gives better service at temperatures ranging around 15° below zero. The following table gives the different temperatures at which these mixtures will freeze:

ALCOHOL

Per cent by Weight	Freezing Point Fahr.
25	-3
30	-9
35	-16
40	-25
45	-36

Cylinders Worn. Almost all the wear comes on the side against which the piston is forced by the angularity of the connecting rod during the lower stroke. Moreover, the wear is likely to be greatest in the middle of the piston's travel, particularly if the piston wall has not been relieved at its middle portion to concentrate the pressure at the ends. For this reason it is not enough, when a cylinder is suspected of being out of round, to caliper across two diameters at right angles to each other. It must also be calipered at the top, middle and bottom of the piston's travel. If the cylinder is worn oval to about the same extent throughout the piston's travel, it is still possible for the rings to fit after a fashion, but if when the rings fit tightly at one portion of the stroke they are open at another portion, leakage inevitably results, and it is time to re-grind the cylinders. If the diameter of the cylinder is not increased more than two or three-thousands it is possible that the old piston can be used by simply fitting new rings. A greater enlargement, however, requires for durability and quiet running that a new piston be made and fitted. The location of valves and design of the cylinder head has quite a little to do with the wearing of the walls, this being due to the peculiarities in expansion due to contour.

Cylinder Oil Testing. There are really two parts to the fire test, as it is called. One is the test for flash point. This may be determined

as follows: Take two pieces of glass of the same size, and large enough to cover a small glass beaker. In one of them cut a couple of notches. These are for two purposes. One is for the thermometer and the other for the flash point determination. Insert a thermometer in the beaker, filled with the oil under test. Place the notched glass over this and the other piece of glass over that, taking care to cover the notch not in use. Now uncover this notch, note the temperature, and apply a lighted match to the opening. If nothing results, warm the oil slowly over a flame to a higher temperature and take another trial and reading. Continue the test until upon the application of the lighted match the oil vapor over the oil flashes. The thermometer reading at that point gives the flash point. The glass plates may now be removed, and heating continued. The match is applied at similar intervals, until finally the oil burns, which will usually occur at about 50 degrees above the flash point.

An additional test is for precipitation at a known temperature. This is also made in a beaker. Two ounces is the usual amount. It is heated to the desired temperature, at which the oil may change color, but must not show a precipitation. Still another good oil test is the evaporation test. This is the result of slow heating, and the usual specification is that the oil shall not lose over 5 per cent. of its volume when heated to 150 degrees Fahr. for 12 hours.

Flash point, burning point and precipitation vary with the service for which the oil is intended, thus air-cooled motors always require a much higher oil test than those for water-cooled machines. As this is some indication of the quality, it is higher priced and harder to obtain, both in purity and evenness, and as a matter of convenience. Three hundred degrees is about the lowest flash point that should be accepted. With this would go 350 to 400 burning point and about 500 precipitation lower limit. In fact, oils may be had for any desired flash point and burning point up to 450. Beyond that they are hard to obtain. It is frequently claimed that this, that or the other oil will test 800 degrees, meaning the burning point. In the face of this statement, a simple home test as outlined above will determine at once the quality of the oil.

Dalton's Laws. The relation between the vapor tension and the quality of vapor is expressed by two laws known as Dalton's laws, as follows:

I. The pressure, and consequently the quantity, of vapor that will saturate a given space are the same for the same temperature, whether the space contains a gas, or is a vacuum.

II. The pressure of the mixture of a gas and a vapor is equal to the sum of the pressures that each would exert if it occupied the same space alone.

If a volatile liquid is added to a gas, and the

resulting mixture of gas and vapor is allowed to expand so that the pressure remains unchanged, the volume of the mixture will exceed the original volume of the gas. The ratio of this new volume to the original volume of the gas is equal to the ratio between the combined pressure of the gas and vapor, and the pressure of the gas alone, had the volume remained constant.

Deposits in Water Jacket. If the cooling water contains lime or alkali, the heating of the water in the jacket will cause these solid substances to be deposited in the cooling spaces. This will soon choke any narrow ports and prevent proper circulation, resulting in overheating, rapid wearing of the valves, and loss of power and efficiency. A simple remedy consists of the application, at regular intervals, of a dilute solution of hydrochloric, or muriatic, acid, made as follows: Dilute one part of muriatic acid with nineteen parts of water, and, after draining the jacket completely, pour in enough of the solution to fill the entire cooling space. Allow the mixture to remain in the jacket for not more than 8 to 12 hours, after which wash the cooling space thoroughly by running clear water through it. If the solution is permitted to remain in the jacket longer than the period stated, there is danger that the metal may be damaged by the action of the acid. The acid will soften and dissolve the lime or alkali, and the clean water will remove it from the jacket.

It is generally sufficient to apply this method of removing the deposits once every two weeks. If neglected too long, the acid will not dissolve the deposit.

Differential Gears. So long as an automobile moves in a perfectly straight path, its two driving wheels turn at equal speed, since they must cover equal distances in equal periods of time, and it would be perfectly allowable that the two wheels should be locked together, as there would be no relative motion between them. The power could be transmitted to either one, or to both of them with perfectly satisfactory results under these circumstances. When, however, a car is to be moved in a curved path, as in turning a corner, the driving wheels must move at different speeds, since the outside one has to cover a longer distance in the same time than does the wheel which is on the inside of the curve. If the two wheels were locked together under these conditions, one or both of them would be forced to slip, as the speeds transmitted to them would be equal, while the distances they are to travel are unequal. This difficulty is successfully overcome by the use of the differential gear which transmits the power from the change-speed gear to the rear axle, or driving wheels of the car. Differential gears consist of a set of four or more gears attached to the ends of two shafts that meet, and are usually in line, so that both are rotated in the same direction. But, if

either meets with extra resistance it may rotate more slowly than the other, or may stop altogether.

These gears are used on the driving axles of automobiles. The axle is made in two parts, with a gear on the end of each, where the parts come together. Other gears mesh with both these axle gears, and are driven from the engine by a sprocket and chain, or by bevel gears and shaft. These gears turn the axle, but permit its two parts to turn in respect to each other so as to allow the automobile to go around a corner without causing the wheels to slide, or skid. The rear wheels are each fixed to a half of the rear axle, and both receive power, hence it is necessary to allow one wheel to turn at a different speed from the other, and this is accomplished by means of the differential gear.

Bevel Gear Differential. Fig. 118 shows a semi sectional view of the bevel differential gear. The engine shaft carries a bevel gear wheel shown in section at a. This gear meshes with the large bevel gear b, on the differential gear case c. On the inside of this gear case are carried a number of small bevel gears, one of which is shown in section at d. These are free to turn on the studs that hold them to the gear case. These gears in turn mesh with bevel gears e and f, on the ends of the half axles.

The principle governing the action of the bevel gear differential is similar to that of the

spur gear differential. When the two bevel gears e and f on the half axles meet with the same resistance, the small bevel gears d do not turn on their bearings; but when the movement of one of the gears e or f is resisted more than

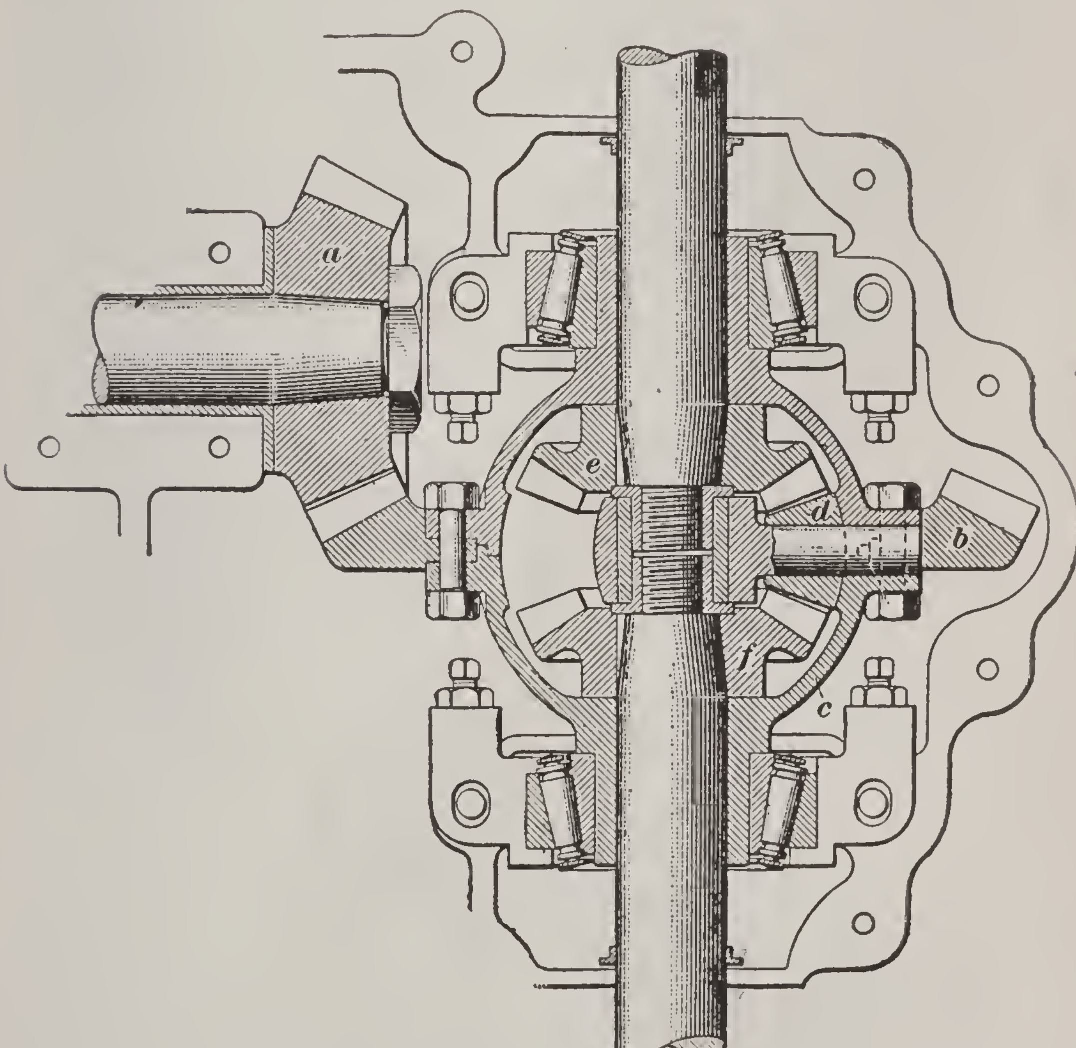


Fig. 118

that of the other it lags behind, causing the small bevel gears d to turn on their axles sufficiently to equalize the resistance.

Spur Gear Differential. In the spur differential, bevel gears are replaced by gears of

the spur type, as shown in Fig. 119, a large spur gear being secured to each half axle, as shown at A and B, exactly as are the bevel gears. A double set of spur pinions, E and F, having their bearings in the frame, revolve

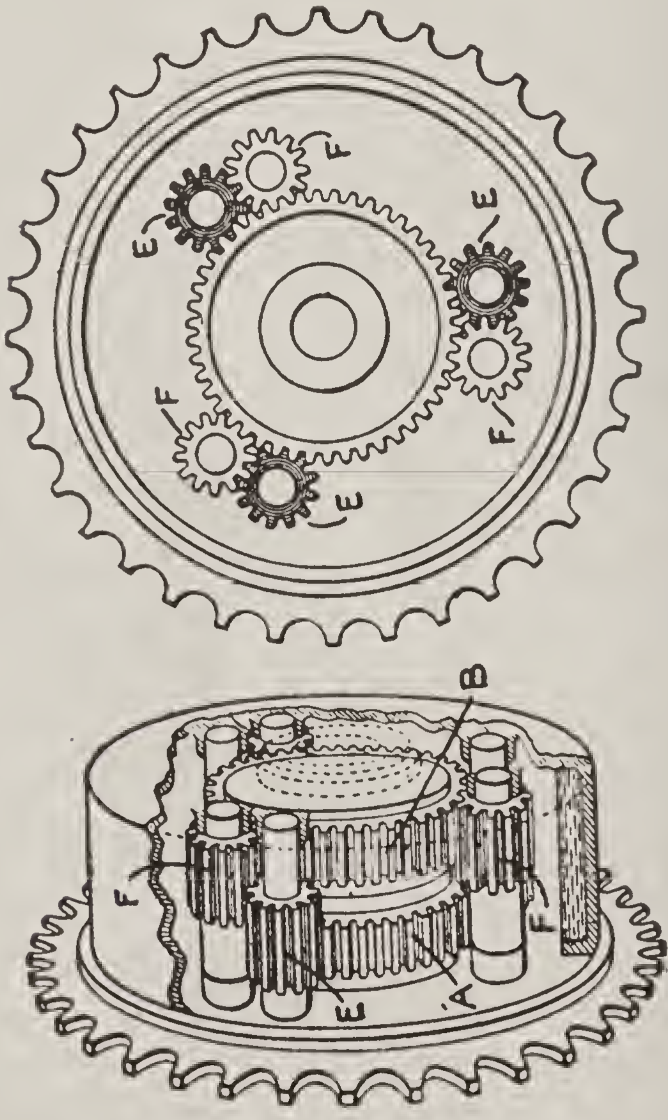


Fig. 119
Spur Gear Differential

upon axes parallel with the axle. For each bevel pinion is substituted a pair of spur gears, E and F, which mesh with each other, and at the same time each one of them is in mesh with one of the large gears. The combination of the

motion of each pinion of the pair upon its gear, and the motion of the pair upon each other produces the same effect as the use of a bevel pinion. When the vehicle is rounding a curve, one rear wheel moves less rapidly, causing the pinions with which it is geared to revolve upon their bearings, and thus compensate for the increased resistance.

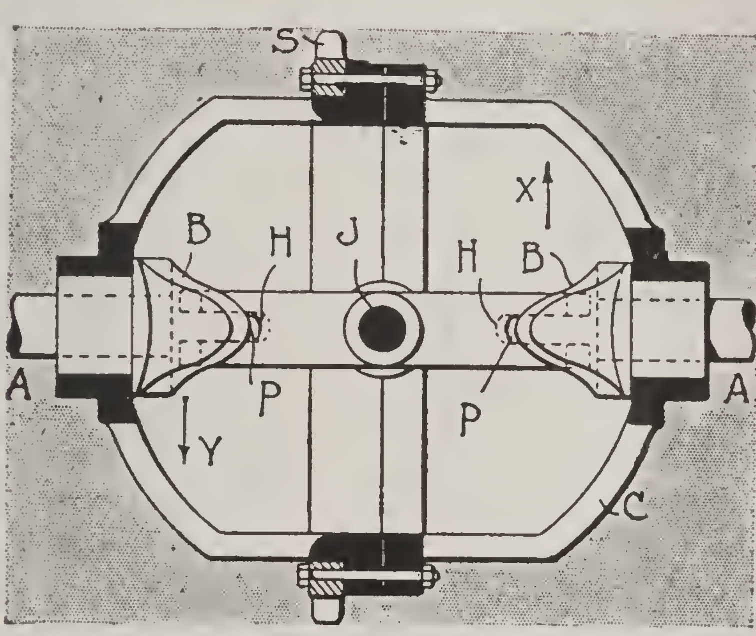


Fig. 120
Russel's Gearless Differential

Russell's Gearless Differential. The action of this device as described by the inventor, H. M. Russell, is as follows: On the half axles A, Fig. 120, are cranks B, one on each. The usual sprocket case C, with sprocket S, carries a pin J diametric to the case, but at right angles to the axis of the vehicle. On this pin is a ring D, Fig. 121, journaled so that it may make nearly a half revolution on the pin, and having its two

free sides slotted at H to receive the crank pins. A peculiarity of the cranks B is that they are arc-shape and in certain positions lie concentric with the ring D, while their crank-pins P are not parallel with the rear axle which is the main shaft in this case, but are radial to the center of the ring D and case C. The ring serves to send half the power to each

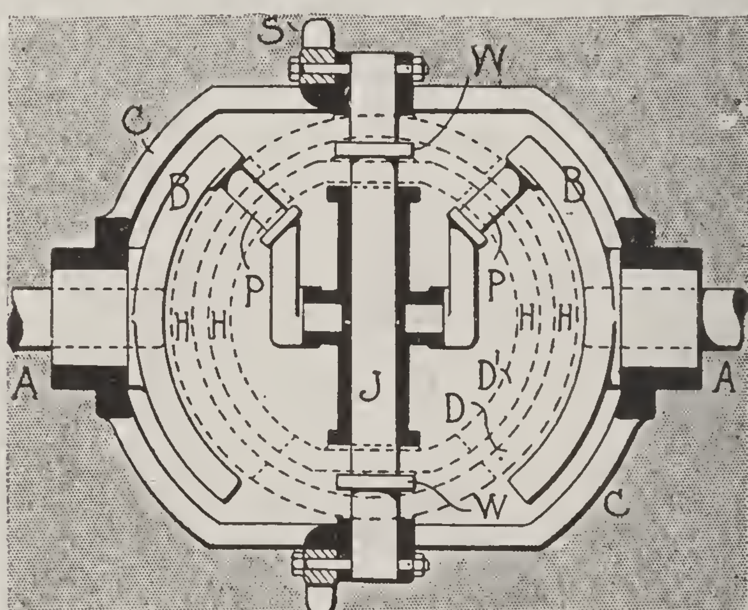


Fig. 121
Russel's Gearless Differential

crankpin P just as did the bevel pinion. A little thought will show that the ring will transmit no power when the crankpins P are moving lengthwise the slot H, as they will be when at right angles to the ring pin. A second ring therefore is placed inside the first and the slots are cut at an angle to each other, D^1, Fig. 121. By this arrangement any position of a crankpin

on one side must be met by the pin on the other side so the balance is maintained.

Again referring to Fig. 120, it will be seen that since the center planes of the slots H also pass through the center of the device, the mechanism will be removable, and the crankpins P,

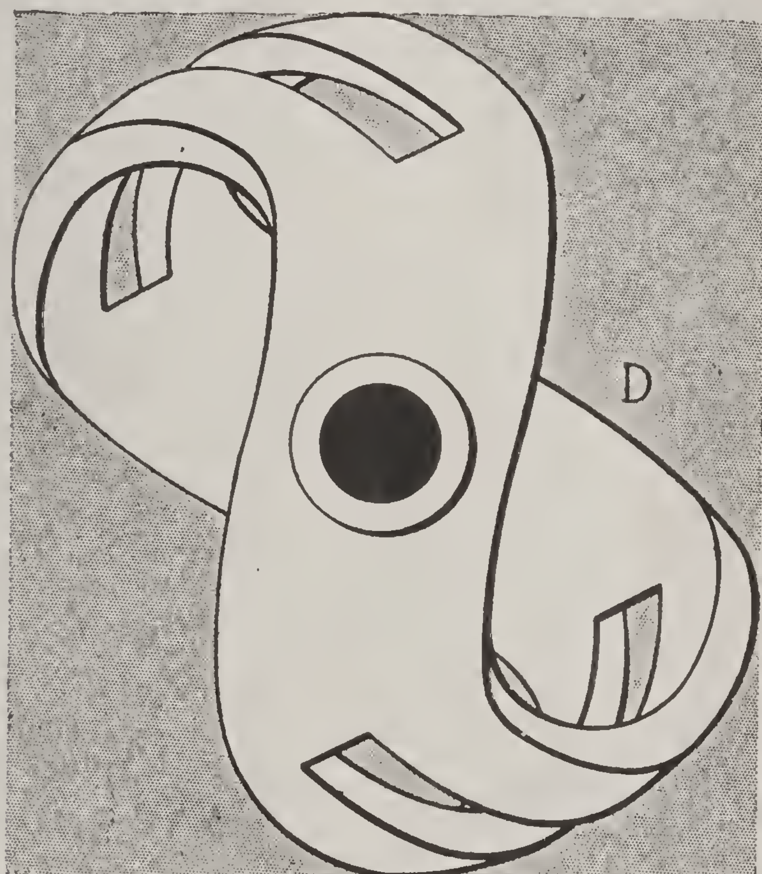


Fig. 122
Top View Russel's Ring

if they fit the slots H in one position, must fit them in any position which the cranks occupy. It is also clear that since the device is symmetrical that the cranks B if they move at all must have equal and opposite movement. Assume the cage C to be stationary and the right-hand

crank B to turn towards the top, in direction of arrow X; this will tilt the ring out of its horizontal plane, and the opposite side of the ring will push the left crank B down in direction of the arrow Y, through the same angle as the right crank B took. This shows there is a

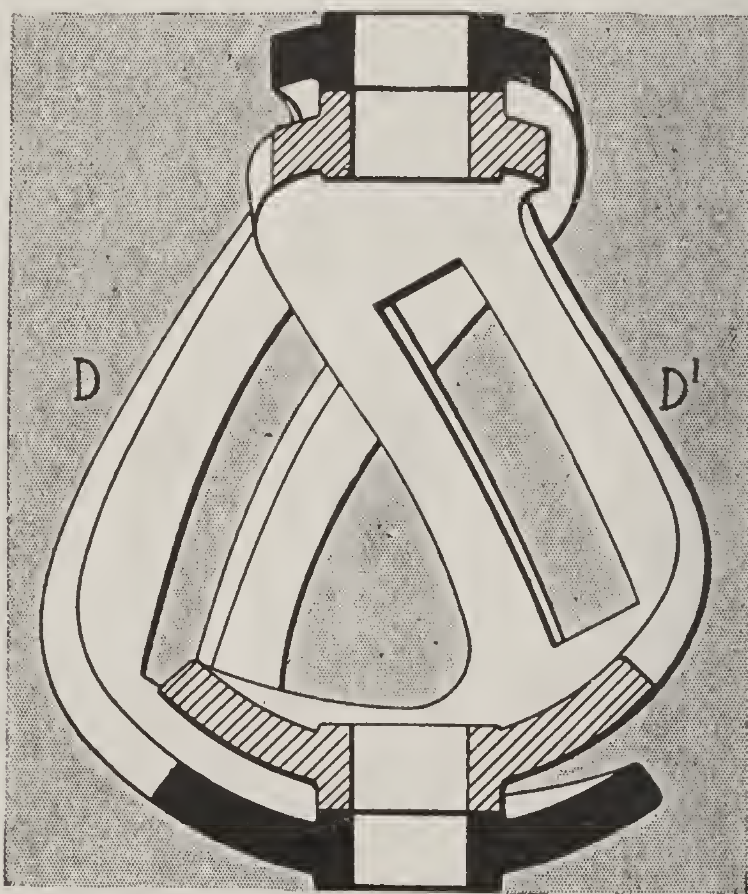


Fig. 123
Vertical Section of Russel's Ring

perfect differential. It will be seen that when these cranks B have turned 90 degrees in the opposite direction, the ring D will be vertical in the illustration and a dead center will be the result. This has been overcome, as illustrated in Fig. 121, by using two rings D and D¹, the

latter inside of the former. This illustration shows the complete device, except that the dotted lines merely indicate the general position that will be occupied by the rings D and D^1, which are held separate by washers W. Fig. 122 shows a top view of the ring D and it will be seen that the slots H, instead of being parallel to the axis of the oscillation of the ring are turned to an angle of 30 degrees of this axis; the effect of this is to make the dead center occur when the cranks are 90 degrees apart instead of when they are 180, as shown in Fig. 120. Fig. 123 is a cross section of the rings D and D^1 and shows the relative position of the slots H in the two rings. It will be seen that these slots in one ring are placed somewhat like the threads on a double thread right-handed screw, while those in the other ring are placed like the threads on a left-handed screw. The effect of this is to make the dead centers of the two systems come 90 degrees apart, and so produce continuous rotation.

There are still other forms of differentials, but these are the simplest and most common of the type that, while positively controlling the wheels of the vehicle, send half the power to each at all times regardless of their respective movements.

Testing Differential Gears. The differential gear should be tested with a view to locating any wear or side play. This may be done by jacking up the rear axle and shaking one

wheel forward and backward while the other is held stationary, and noting how far the wheel must be turned before the movement is taken up by the flywheel of the engine. Any noticeable play will generally be found either in the center pinions of studs of the differential gear, in the large and small bevel gears, in the clutch sleeve, or in the universal joints. The differential gear, and live axle of modern cars seldom give trouble if kept properly lubricated, and the car's mileage should run up into many thousands before any considerable amount of play is evident. The joint pins of the propeller shaft may become loose through wear, in which case a knocking noise in the transmission gear will indicate the cause and location of the trouble. These pins may be readily replaced with new ones at small cost. If the play is found in the bevel gears, the small gear should be adjusted to mesh deeper with its larger mate. This may be done by means of the adjustable locking ring or by inserting a washer of the proper thickness. It may be found, however, that no adjustment is necessary, and a thorough cleaning with gasoline to remove all oil and grease will be all that is required. The case should then be refilled with the quantity of oil and grease recommended by the manufacturers.

Distributers. Instead of employing a separate spark coil for each cylinder of a multi-cylinder engine, the primary circuits of which

are made and interrupted in rotation, a device known as the distributer may be used, which permits of any number of cylinders being sparked from a single coil. In magnetos designed for jump spark ignition of multi-cylinder engines the distributer forms part of the magneto and is rotated by it. The distributer is nothing more than a timer of secondary current, and generally consists of a cylindrical shell of insulating material, upon the inside of the cylindrical surface of which equidistant metallic segments in number equal to the motor cylinders are inserted. A conducting arm rotating upon a shaft concentric with the insulated shell carries a brush, which successively makes contact with the segments. The arm is in permanent electrical connection with the free secondary terminal of the coil, and each one of the segments is wired to the spark plug of a cylinder.

In the case of four-cylinder motors the moving arm is geared at one-half the speed of the motor, thus making contact for each cylinder once in each two revolutions or complete cycle.

Don'ts. In the first place don't forget to ascertain the fact that the ignition mechanism is retarded before cranking the motor. Many a sprained wrist and not a few cases of broken heads or arms have been caused by the neglect of this simple precaution. It is a good plan to

have the ignition-control spring so actuated that in its normal position it is always retarded.

If the motor should not happen to start the first time, don't forget to keep out of the way of the crank when the motor is stopping. It might take a turn backwards and take the crank with it.

Don't forget to close the battery switch before starting the motor.

Don't allow the motor to stand in such a position that with the battery connected, the vibrator of the spark coil will work. It is almost the same as a short-circuit, and will run down the battery rapidly.

Don't use a match or a small torch to inspect the carbureter. It sometimes leads to unexpected results.

Don't forget to fill the gasoline tank before starting.

Don't smoke while filling the gasoline tank.

Don't take out all the spark plugs when there is nothing the matter, except that there is no gasoline in the tank.

Don't forget to always have an extra spark plug on the car.

Don't allow the motor to race or run fast when out of gear. If the car is to be stopped for a few minutes, without stopping the motor, retard the ignition and also throttle the charge, so that the motor will run as slowly as possible.

Don't fill the gasoline tank too full, leave an

air space at the top or the gasoline will not flow readily.

Don't have any open hole in the gasoline tank. When the car is washed water may run in this hole, mix with the gasoline and cause trouble.

Don't put grease in the crank case of the motor, it will clog up the oil holes and prevent the oil from circulating.

Don't fill the gasoline tank by lamp or candle light, something unexpected may happen.

Don't keep on running when an unusual noise is heard about the car, stop and find out what it is.

Don't start or stop too suddenly, something may break.

Don't pour gasoline over the hands and then rub them together. That rubs the dirt into the skin. The proper way to do is to saturate a towel with gasoline and then wipe the dirt off.

Don't forget to examine the steering gear frequently.

Don't fail to examine the pipe between the carbureter and the admission-valve occasionally. The pipe connections sometimes get loose and allow air to enter and weaken the mixture.

Don't forget to see that there is plenty of water and gasoline in the tanks.

Don't fail to clean the motor and all the wearing parts of the car occasionally.

Don't forget to oil every part of the motor

where there is any friction, except the valve stems.

Don't spill gasoline on the clothing and then strike a match to light a pipe, some one may be sorry afterwards.

Don't go out for a run without a complete equipment of tools, extra parts, gasoline, and tire repair outfit, or a late return may be expected.

Don't let a willing bystander fill up the gasoline tank with water.

Don't leave the water in the circulating system on a frosty night, except with 40 per cent of gylcerine in it, and never when below zero.

Don't start away with the brake on and wonder why the motor is not working well and in conclusion,

Don't let the starting handle fly off and hit somebody on the chin.

Driving—General Rules for. When on the open road, away from cities or towns, the following rules should be borne in mind. (1) Drive with moderate speed on the level, slow speed down hill, and wide open throttle for hill climbing, or getting up speed only. (2) The condition of the road should be noticed, the presence of mud or dust thereon furnishing sufficient reason for slowing down somewhat for the sake of other road users. (3) The ordinary rules of the road regarding the negotiation of turns, and crossings, also the overtaking or passing of other vehicles should be ad-

hered to, even though a lower rate of speed is involved thereby. (4) A sharp lookout should always be kept for traffic of all kinds, as well as on approaching schools, churches, or public buildings, and also for road signs indicating danger, caution, etc. (5) When on the road the autoist should show courtesy to other road users. Courtesy in autoists is much appreciated, and goes a long way toward removing the prejudice which exists in many places against automobiles.

Driving-wheels, Large versus Small. The larger the wheels, the less power should be required to drive a car. Theory shows that the road resistance decreases in proportion as the wheel diameter gets larger. The result of experiments to verify this do not show quite such favorable results, but a gain almost in proportion to the square root of the wheel diameter has been obtained. The principal reasons why large wheels are not more used are as follows:

The center of gravity of the car is raised and makes the car less stable in turning corners. They are more expensive and more liable to injury than wheels of smaller diameter. They increase the cost of the tires enormously. They make access to the seats more difficult on account of the increased height of the car.

Dynamometer. A dynamometer is a form of equalizing gear which is attached between a source of power and a piece of machinery when it is desired to ascertain the power necessary

to operate the aforesaid machinery with a given rate of speed.

E. C. B. Carbureter. Fig. 124 shows a sectional view of the E. C. B. carbureter in which there are three air inlets. A is the normal inlet, in which the air current is converged at the nozzle. C and D are two openings, each having a sliding throttle for purposes of regulation. C is for cold air, D is for heated air, and the

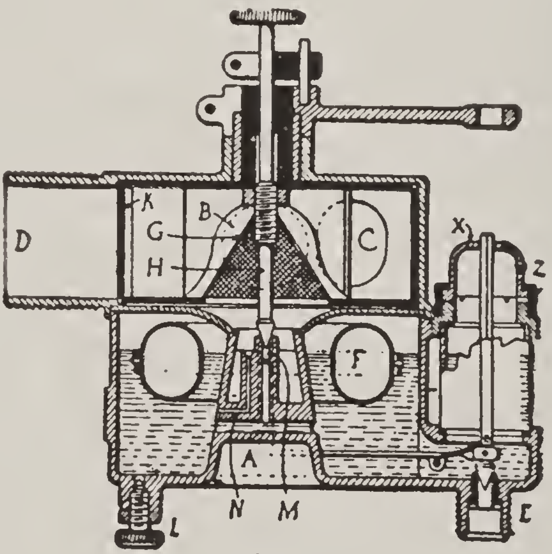


Fig. 124
E. C. B. Carbureter

valve controlling these openings may be set for a maximum of cold air, and a minimum of heated air. or vice versa, according to the temperature of the atmosphere. The engine connection B is ordinarily supplied without a throttle, although, if desired, a throttle K is furnished. The main feature is to control the entering air, rather than the mixture passing to the engine. In addition to its threefold inlet, this carbureter has two spraying nozzles. The

small one N, always open, and just large enough to keep the motor in motion when running idle, and the larger one M, which is controlled by needle valve H, which is raised and lowered as the air entrances are varied. G is a conical wire screen, the purpose of which is to prevent back firing. The openings of nozzles M and N are both well above the bottom of the float chamber.

Gasoline enters by connection E, being controlled by a needle valve operated by float F. The level of the gasoline is visible through the glass portion of the casing, which is marked with graduations. The float level is adjustable by loosening lock nut Z, which holds cone over X, which latter acts as a guide for the stem of the needle valve. Guide X rests in a series of slots, and by raising it out of one slot, and turning it through part of a revolution until in position to drop into another slot, the level of the gasoline is changed.

Economy Carbureter. This carbureter has two spraying nozzles, N, N, Fig. 125, located side by side, the tip of one extending into a strangling tube of much larger capacity, the outlet of which is controlled by a flap valve F, that remains closed when the machine is running light, but when the demand for fuel increases, this valve opens, and both nozzles furnish the supply. In other ways this carbureter follows the usual construction.

Efficiency of a Gasoline Motor. In text-

books the efficiency of a motor is usually considered as the relation between the heat-units consumed by the motor and the work or energy in foot-pounds given out by it. If the heat-units (which are measured by the quantity of fuel supplied to the motor) be large compared to the work or energy given out by the motor, its efficiency is small.

At the present time the quantity of liquid fuel consumed by an explosive motor for auto-

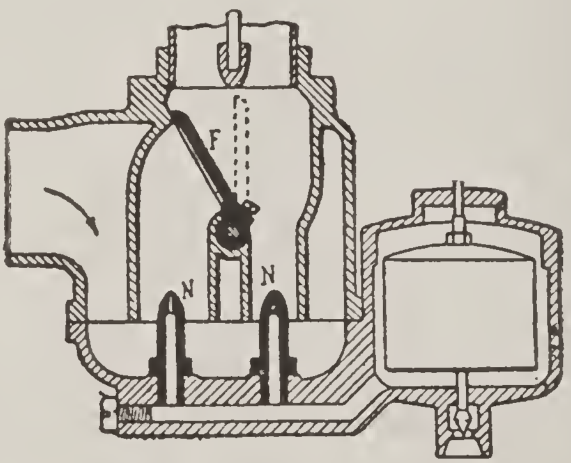


Fig. 125
Economy Carbureter

mobile use is of secondary importance. The fuel economy of a motor is important, but it does not usually occupy the first place in automobile construction. The consideration of primary importance is to obtain the maximum amount of power from a motor of minimum weight. As only about one-fifth of the heat-units consumed by an explosive motor are utilized, or given up in the form of work or energy, there is consequently room for great improvement.

The power for weight efficiency of a motor increases almost in proportion to the speed with high speed explosive motors, but the fuel efficiency of a motor decreases with the speed beyond certain limitations.

Electricity, Forms of. Electricity or electrical energy may be generated in several ways—mechanically, chemically and statically or by friction. By whatever means it is produced, there are many properties which are common to all. There are also distinctive properties. The current supplied by the storage battery will flow continuously until the battery is practically exhausted, while the current from a dry battery can only be used intermittently; that is, it must have slight periods of rest, no matter how short they may be.

The dynamo or magneto current is primarily of an alternating nature, or one which reverses its direction of flow rapidly. In use, this alternating current is changed into a direct or continuous current flowing in one direction only, by means of a commutator. Any of the forms described are capable of igniting an explosive charge in a motor cylinder, but the static or frictional form of electricity is not used for this purpose on account of its erratic nature.

Electric Apparatus—Care of. The following instructions apply particularly to electric apparatus in connection with the operation of automobiles. Look over the electrical plant and replace worn wires with new. Clean out the

timer with gasoline and lubricate with light oil. The magneto need not be taken apart, as it will probably only need a little surface cleaning, a few drops of oil, and the amateur had better not meddle with its internal mechanism. The storage battery should be examined, and if the brown deposit collects in any quantity at the bottom, the electrolyte should be poured out into a glass bottle, and the battery washed out with clear water (rain water preferred). Clean the top of the battery and make it a point to keep it clean and free from acid. Clean the terminals of any corrosion, and see that the air vents are not clogged up. If the accumulator has been neglected, either in the electrolyte having been allowed to get below the proper level or in not giving it the regular monthly "charge," it may get a bad case of sulphating.

To get the battery into its normal condition, empty out the electrolyte and wash the case thoroughly with soft water. Pour in only about seven-eighths of the acid solution and fill up with distilled water to cover the top of the plates. The battery should then be charged with a low current until the plates are restored to their normal condition. If very badly sulphated, the white coating should be washed off with a rag, and in case this fails to remove it, scraping must be resorted to. If the electrolyte is not sufficient to cover the top of the plates, fill up with distilled water so that the liquid will just cover them. The specific grav-

ity of the electrolyte should not be less than 1.150, and, although varying somewhat, a hydrometer reading of 1.250 is recommended. This is approximately 1 part of sulphuric acid to 4½ parts of water, which will be found sufficiently accurate if no hydrometer is at hand. If the electrolyte should test lower than the first figure, add pure sulphuric acid until the 1.250 mark is reached.

In case the plates are broken down or "buckled," or if the paste has dropped out of the pockets of the grids, the accumulator should be sent to the manufacturers for repair. In some accumulators the liquid is not used, but a jelly made of silicate of sodium and dilute sulphuric acid takes its place. If your battery is of this type, it is well to remember that the jelly must be kept moist on the top, and as the emulsion becomes dry a little water should be added to replace that which is lost through evaporation.

The contact points of the coil will probably require adjusting. This is very easily accomplished by trimming up the points with emery paper. Do not rub away the metal unnecessarily, only removing enough to true the points so that they make a good contact. In adjusting the vibrator, remember that a light tension is much better than a stiff tension. A light flexible vibration with a moderately high-pitched buzzing note will not only give a better spark, but will keep the points in better shape.

A heavy tension will make the coil less responsive and will pit the contact points and exhaust the battery more quickly. As a coil will render the most efficient service only when the vibrators are adjusted as nearly alike as possible, a special ammeter is often used to determine the current consumption of each unit. The ammeter should show a reading of 6-10 amperes.

Electric Lamps. It is well to remember that electric lamps consume a great deal of power. One 16 candlepower lamp requires about one-twelfth of a horsepower to operate it. The electrical energy required per candlepower is a trifle over 4 watts. A 4-volt, 4 candlepower lamp would require a storage battery of 24 ampere-hour capacity to enable the lamp to burn 6 hours. The same battery would run a 4-volt, 1 candlepower lamp 24 hours.

Electric Motors. A well designed electric motor for use in connection with a storage battery for automobile propulsion must be capable of withstanding an overload of over 100 per cent for at least thirty minutes at a time, or for even a longer period, without unduly overheating. The motors used on electric automobiles are usually series-wound, as this type of winding has been found to give the most satisfactory results in general use.

There are three types of electric motors in general use, these are:

Shunt-wound motors, in which the field-magnets are wound with a great many turns of

very small wire, the ends of which are directly connected to the terminals of the commutator brushes.

Series-wound motors, which have the field-magnets wound with a few turns of very large wire. One end of this wire is connected to one commutator brush terminal. The other end of the wire on the field-coils, and the other brush terminal being connected with a battery or other source of current.

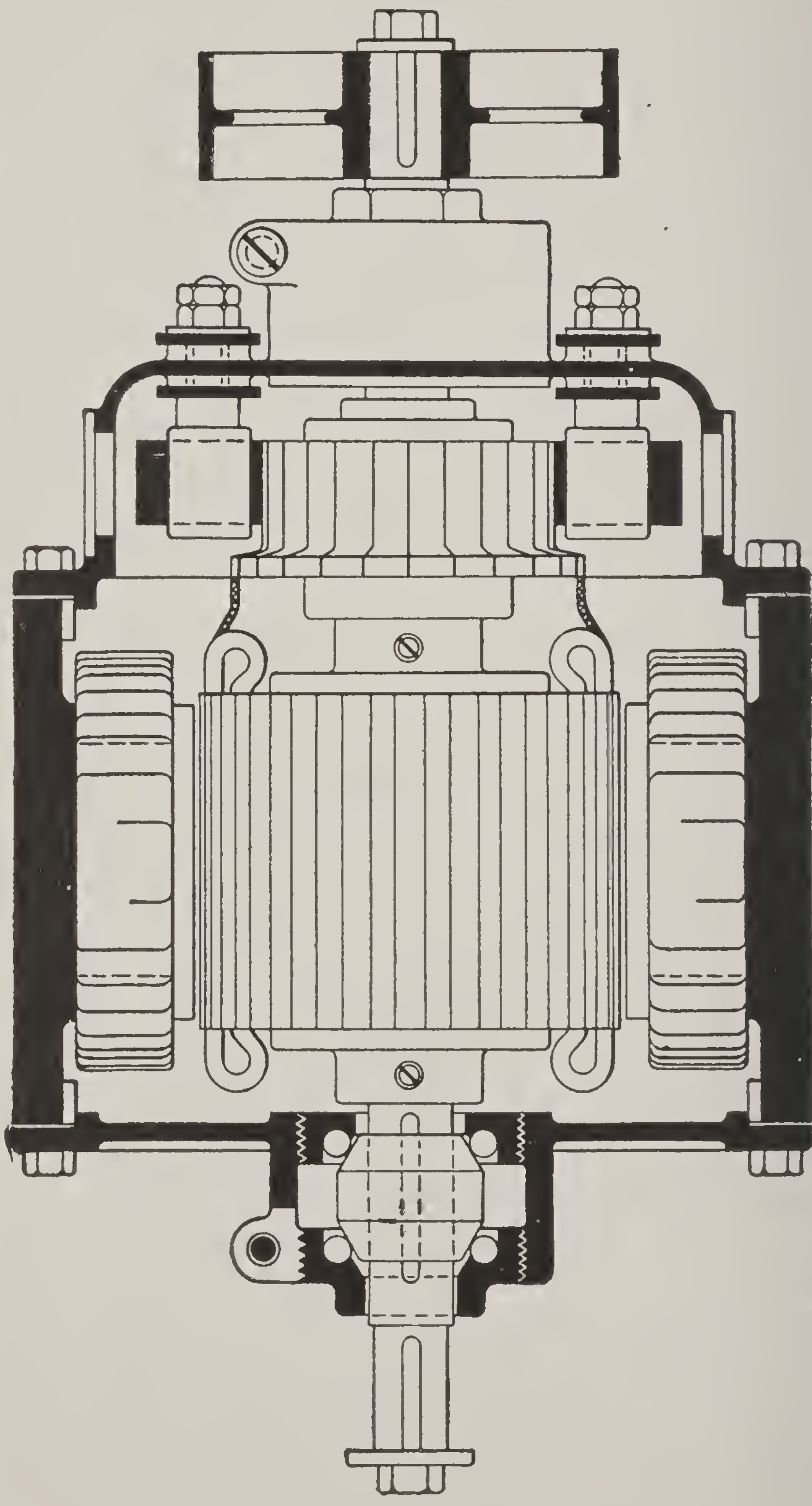
Compound-wound motors are a combination of the above motors, having the field-magnets double-wound, that is with both shunt and series-windings.

The armature of an electric motor is built up of a number of disks of sheet iron, which are separated from each other by a suitable coating of varnish or by the use of thin sheets of paper between the disks, this is to prevent what are known as eddy currents, which are a source of constant trouble if not eliminated.

The function of the commutator of an electric motor is to receive the current from the battery or other source of power, by means of the brushes, and transmit it to the windings or coils upon the periphery of the armature.

The essential features of an electric motor are as follows:

The brushes, which are located upon and around the periphery of the commutator and serve to transmit the current to the commutator from the outside source of supply.



ELECTRIC MOTOR

Fig. 126

The commutator or current distributor, and laminated wrought iron armature.

The field-magnets and pole-pieces; the latter are usually an extension of the magnet core.

The magnet frame, usually of cast steel.

Figure 126 shows a form of series-wound electric motor of the style most commonly used for automobile work. The motor is of the four-pole type, having its field-coils arranged at equi-distant points around the periphery or circumference of the armature. The armature shaft is carried by ball bearings, with suitable screw and clamp adjustment as shown. The armature is of the slot-wound type and has a commutator with self-adjusting carbon brushes. The left-hand extension of the armature shaft is fitted with a key and washer for the driving gear or sprocket, while the right-hand end has a pulley or brake wheel to use for stopping the car under ordinary conditions of travel. The magnet frame is of cast steel, and the magnet cores and armature disks of laminated wrought iron. The field-coils are machine-wound, and the armature coils form-wound, while both are thoroughly taped and waterproofed. The commutator generally has the same number of sections as the armature has slots and is usually of large diameter and wide contact face.

Electric Motor Troubles. Electric motor troubles may be classed as follows: Open-circuits, improper connections and short-circuits.

An Open-circuit may be found at any one of the following places:

Battery terminals. These may be badly corroded or worked loose, so as to form a poor or improper electrical contact.

Controller. A connection may have worked loose, or the spring contact-fingers are not making good contacts.

The removable plug may be out or not making a proper contact.

Brushes. One of the carbon brushes of the motor may have fallen out, or the brush springs may be too weak to insure a good contact.

The reversing switch may be halfway over, thus leaving the batteries and motor on an open circuit.

All points of contact, such as terminals or binding-posts, brush-holders, switches and controller spring contact-fingers, should be bright and clean so as to give a perfect metal-to-metal contact.

The fact that the car will not start and the ammeter shows no current indication is generally an indication of improper battery connections.

When the different trays of the battery are not properly connected together, short-circuits will occur between these sections and run down or exhaust the batteries in a very short time. All battery terminals should be plainly marked so that it is impossible to make wrong connections. If the trouble above stated occurs the

battery trays must be wrongly connected amongst themselves.

If the ammeter indicates a large current and the motor refuses to turn, the trouble is what is known as a short-circuit, or a path for the current outside of the motor.

Lift one of the commutator brushes, and if the amperage shown by the ammeter drops, or perhaps disappears altogether, one of the field-coils is short-circuited or there is a broken wire touching some part of the metal of the car or an exposed portion of another wire.

ELECTRIC MOTORS, SPEED-REGULATION OF. The speed and consequently the power of an electric motor may be varied in three ways, as follows:

First, by introducing variable resistances in the motor and battery circuit.

Second, by varying the voltage of the batteries by different combination of the battery trays.

Thirdly, by connecting the field-coils of the motor; all in series, in series-parallel and all in parallel. Various other combinations of the above named methods may also be had.

Electrical Horsepower. One electrical horsepower is equal to the current in amperes multiplied by the electro-motive force or voltage of the circuit and divided by 746.

Let C be the current in amperes and E the voltage of the circuit. If E. H. P. be the required electrical horsepower, then

$$E.H.P = \frac{E \times C}{746}$$

In practice with motors of small power, 1,000 watts are necessary to deliver one mechanical or brake horsepower at the driving shaft of the motor.

If the actual or brake horsepower of an electric motor be known, the efficiency of the motor may be readily found by the following formula:

If E be the voltage of the circuit and C the current in amperes consumed by the motor, let B. H. P be the brake horsepower of the motor and e the efficiency of the motor, then

$$e = \frac{B.H.P \times 746}{E \times C}$$

Table 10 gives the electrical horsepower of motors with voltage from 20 to 100 volts, and current strengths from 10 to 80 amperes.

The mechanical efficiency of a motor may be found by use of the table as follows

Example: Required the mechanical efficiency of a 40-volt, 60-ampere motor, which is rated by its maker as of 3.25 horsepower—the motor when under full load using 80 amperes.

Answer: Reference to the column in the table corresponding to 40 volts and 60 amperes gives 3.22, while the 80 ampere column gives 4.29. Then 3.22 divided by 4.29 gives 0.75, or 75 per cent. as the mechanical efficiency of the motor.

TABLE 10.

ELECTRICAL HORSEPOWER OF MOTORS.

Voltage	Current in Amperes.							
	10	20	30	40	50	60	70	80
20	.29	.54	.79	1.07	1.34	1.61	1.88	2.14
40	.54	1.07	1.61	2.14	2.68	3.22	3.75	4.29
60	.79	1.61	2.41	3.22	4.02	4.82	5.56	6.43
80	1.07	2.14	3.22	4.29	5.36	6.43	7.50	8.58
100	1.34	2.68	4.02	5.36	6.70	7.94	9.38	10.72

ELECTRO-MAGNETIC VIBRATOR. Gasoline motors with high compression and speed require a jump-spark of greater intensity and volume than those with less compression and speed, to properly ignite the charge. They consequently require a battery of higher voltage and greater current volume to induce a greater flow of the magnetic flux or lines of force in the iron core of the coil. This has the effect of reducing the number of vibrations per minute of the trembler attached to the coil. Numerous tests have shown that when the motor to which such a coil is attached, attains a certain rate of speed, the vibrator refuses to work when the circuit it closed by the commutator on the motor. That is due to the fact that the period of time during which the electrical circuit is closed and opened by the commutator is not of sufficient duration to allow the vibrator to properly perform its function. It is to overcome these objections that the electro-magnetic vibrator, here illustrated and described, is intended.

Figure 127 is a plan or top view, clearly showing the wiring and connections to the terminals

or binding-posts. This is also an important point in the construction, and enables the operator to connect the vibrator to the coil, battery and motor without any chart or previous instructions, and if properly connected as marked, no ground or short-circuit can occur. P and P are the connections to the primary winding of the induction coil; B and B, the battery connections, and C and C the connections to the

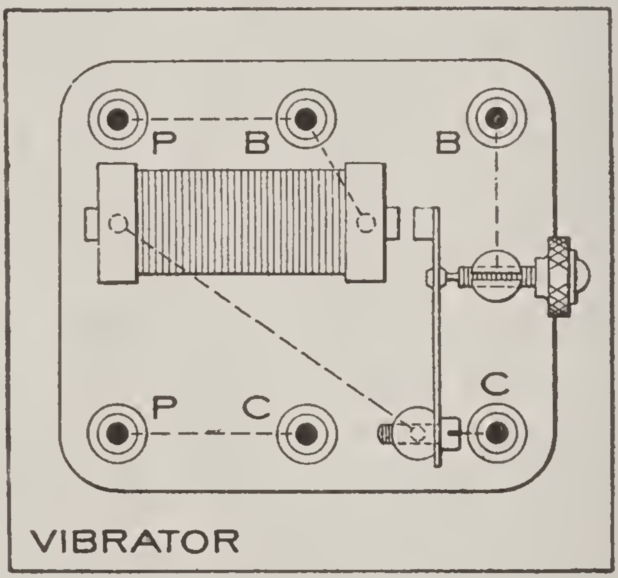


Fig. 127

commutator on the motor. The wiring shown by the dotted lines between the terminals P and B, and also between P and C, are merely blind or dummy wires, so as to prevent any mistakes in the wiring of the car, as all connections between the battery, coil and motor must be made through the vibrator. As this electro-magnetic vibrator is not connected in series with the battery and coil current, but is in a simple shunt from the battery, it utilizes

only a fraction of the battery current, while the remainder of the current goes directly to the primary winding of the coil, and the current used by the coil is at all times controlled by the operation of the vibrator.

The trouble experienced by owners of cars having multi-cylinder motors equipped with the ordinary vibrator or trembler form of jump-spark ignition indicates that something more reliable, more nearly fool proof, and therefore better adapted to the requirements of the automobile maker and user, is required. The use of this device insures the absolute synchronization or timing of the spark in multi-cylinder motors with any number of cylinders.

Electro-motive Force, Definition of. The cause of a manifestation of energy is force; if it be electric energy in current form it is called electro-motive force. An electro-motive force or pressure of one volt will force one ampere through one ohm of resistance.

Engine—Requirements of. An automobile engine should answer the following requirements in order to meet the demands of the motor user: It must be of light weight in proportion to its horse power, so that as large a proportion of its power as possible may be available for propelling the useful load, and but little demanded to move its own weight; it must be compact, in order that it shall not occupy too large a proportion of the available room of the car; it must operate without undue noise

and vibration; it must be fully enclosed as a protection against the weather, and still it must be so located as to be easily accessible for inspection, oiling and repairs; its operation must be automatic for considerable periods of time, as regards cooling and lubrication; it must be capable of running very slowly, or very fast at will, and of developing little, or much power; it must be supported upon the car in such a manner that its power may be most readily and efficiently transmitted to the driving wheels, and it must further be carried upon springs so that the jar and shock from the road shall not be transmitted to it.

Exhaust—Cause of Smoky. Smoke coming from the exhaust of a gasoline motor is due to one of two conditions: Over-lubrication—too much lubricating oil being fed to the cylinder of the motor– or too rich a mixture, that is, too much gasoline and an insufficient supply of air.

The first condition may be readily detected by the smell of burned oil and a yellowish smoke. The second, by a dense white smoke accompanied by a pungent odor.

Exhaust Muffler. When the exhaust gases of an explosive motor are allowed to pass out through the exhaust pipe directly into the atmosphere, the sharp explosions rapidly succeeding each other are very annoying, and it is for this reason that the device termed an exhaust muffler is, or at least should be, used. Various types of mufflers are in use, each no

doubt possessing its own particular merit. The function of the muffler is to deaden the noise of the escaping gases, and the general requirements of the device are as follows: (1) It must be built strong enough to withstand the force of any explosion liable to occur within it, due to the escape of an unexploded charge, which may take place in one of the engine cylinders. (2) It must check the velocity of the escaping gases without causing too much back pressure on the motor. (3) It must deaden the noise.

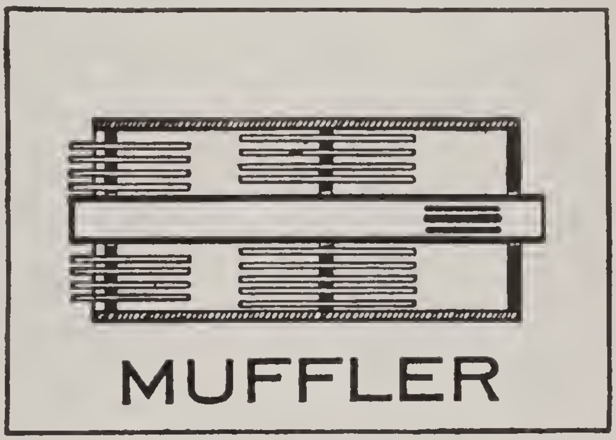


Fig. 128

The last two requirements may be attained by: (a) Breaking up the gases into a number of fine streams: (b) Allowing the gases to expand and cool; (c) Reducing the pressure of the gases, until they are as nearly as possible at atmospheric pressure.

The terminal or exhaust pressure ranges at from 30 to 50 pounds per sq. in. above atmospheric pressure, while the temperature will be 800 to 1100 degrees F.

Figure 128 illustrates a form of muffler with

a central inlet-pipe, provided with slotted openings as shown. The chamber is divided into two parts by a plate, in and around which are located a number of small tubes for the passage

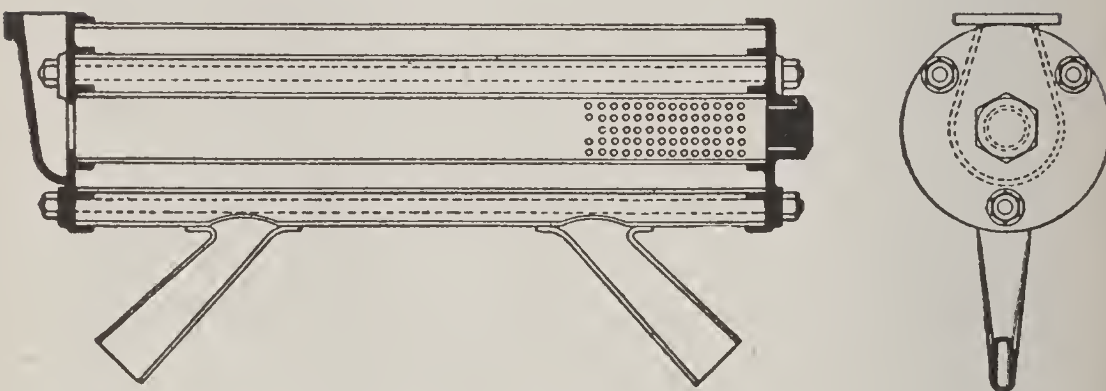


Fig. 129
Concentric Muffler Used on the Studebaker Cars

of the gases. A similar set of tubes are located in the discharge end of the muffler.

Figs. 129, 130 and 131 show sectional views of different forms of the type of exhaust muffler known as the concentric type. The muffler shown in Fig. 129 consists of two or more cyl-

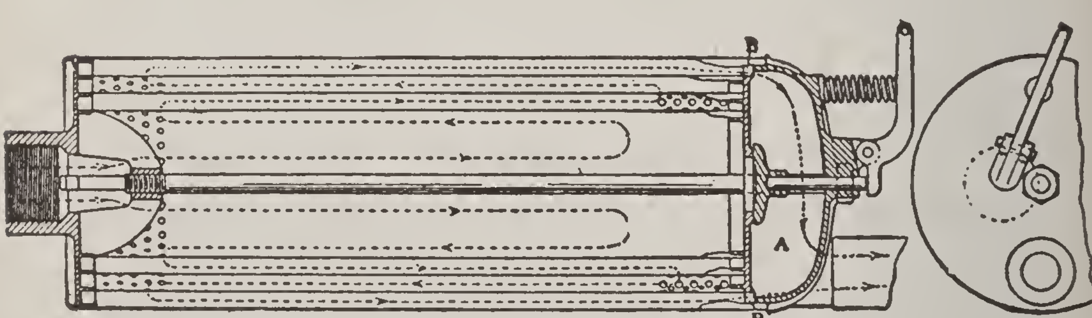


Fig. 130
Concentric Muffler with Cut-Out

inders closed at both ends, there being an entrance into one of them from the exhaust pipe, and an exit from another into the atmosphere, while the exhaust gases pass from cylinder to

cylinder by means of small holes, which serve to break up the gas into small streams. In Fig. 130 the path of the gas is shown by the arrows. It enters the inner cylinder, and its impact is cushioned by the air therein. Returning it passes through a series of small holes into the next larger cylinder. Continuing to expand and cool in this manner, it finally reaches the outer cylinder, from which it passes through another series of holes into the collector cham-

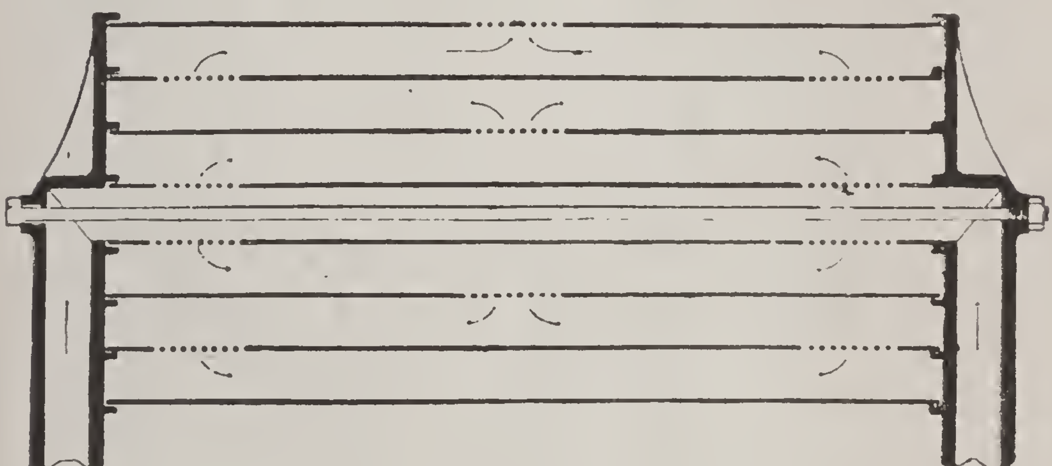


Fig. 131
Friedman Exhaust Silencer

ber A, and from thence it flows out through the tube at the bottom. This tube being located at one side, the gas coming from the different holes B, B has a different length of path from each to the tube, consequently the discharge from holes B, B begins simultaneously, and the discharge from the outlet is gradual.

The Friedman exhaust box (Fig. 131) is an interesting device. A number of concentric tubes or drums communicate with one another through the perforations indicated. The ex-

haust enters from each cylinder at opposite ends of the central tube, from which it diffuses outwards. As the exhaust gases from the two cylinders oppose one another in the inner tube, the noise is almost completely silenced. The exhaust finally escapes through holes in the outside drum.

Fig. 132 shows a sectional view of the Oldsmobile exhaust silencer, in which the exhaust gases enter the free space, and percolate slowly to the outer air through the two bent pipes

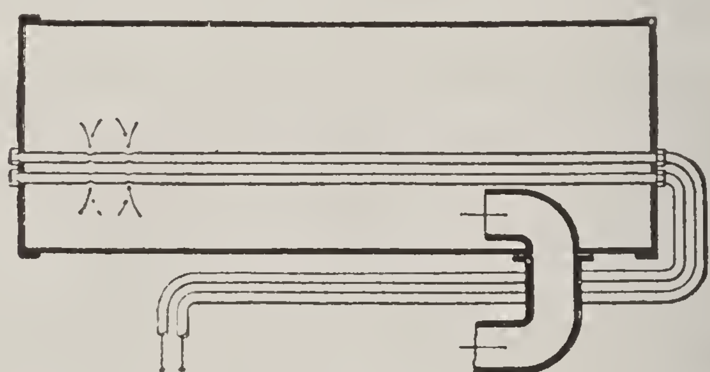


Fig. 132
Oldsmobile Exhaust Silencer

which are perforated near the ends. The ample size, and the gradual passage of the gases account for its efficiency. The Prestwich-Drury exhaust muffler is a cylinder A, Fig. 133, with removable ends. The closed tubes C, D and E, are shorter than the cylinder so that a space G is left between their ends and those of the cylinder. These tubes are shaped to accommodate themselves to that of the cylinder, and they create passages (J, K, L) extending longitudinally. The exhaust gases are admitted near the center of the cylinder as at H, into

one of the tubes and pass out through holes near one end communicating with the adjoining tube, which has holes communicating with the third tube. This has a number of small holes (F)

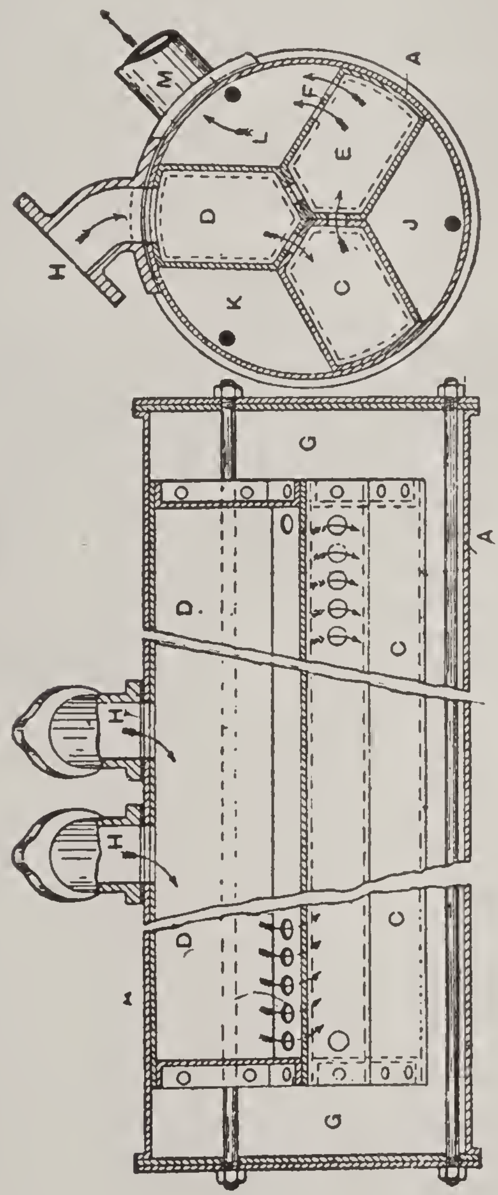


Fig. 133
Prestwich-Drury Exhaust Silencer

communicating with one of the passages (L). After circulating in the outer passages, the now greatly expanded gases pass to the atmosphere through a pipe M, fitted near one, or both ends of cylinder A. Fig. 133 shows a longitudinal

and cross section of the device. The Wainwright exhaust silencer, Fig. 134, is a comparatively elaborate device. The gases pass from the motor through pipe A which branches into B and C. Between the ends of B and C is a chamber D, the dimensions of which vary according to requirements. This chamber is of double-conical form, the flanges at their bases

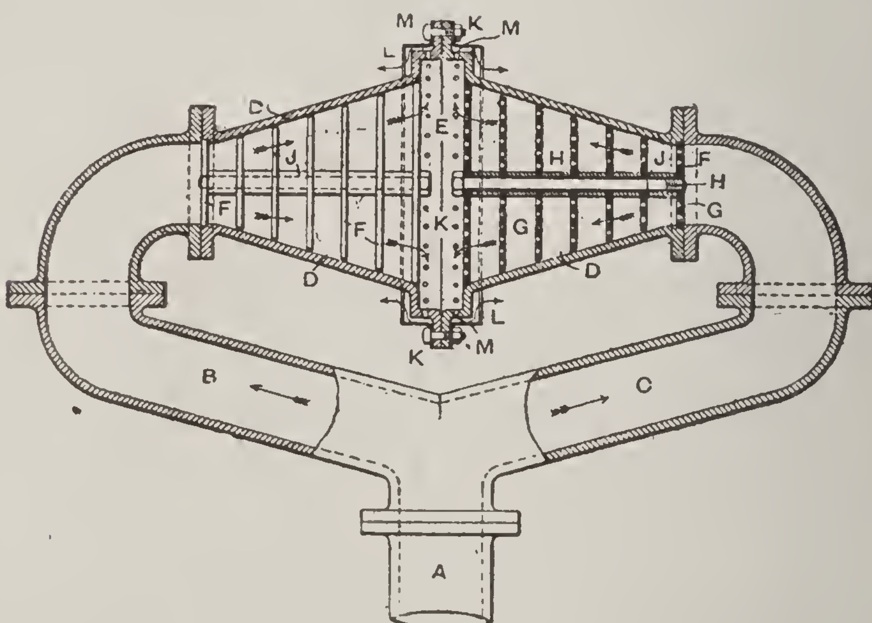


Fig. 134
Wainwright Exhaust Silencer

being secured together by bolts or screws K. The bases E of the conical chambers have holes M, and inside the chamber D are a number of plates F, the conical perforations (G) in which are larger in diameter at the exit side. These perforated plates are supported on central bolts (H), whose external ends are preferably screwed into the end plates. The plates are kept the required distance apart by means of

distance pieces or washers J. Another means of supporting the internal baffles may be adopted if desired. The exhaust gases flow through the pipes A, B, and C through the perforations in the plates F, and out through the perforations M in the chamber D to the atmosphere. In doing so the gases become broken up. The rain shields L, secured by bolts K, do not obstruct the passage of the gases, which pass through them in the direction indicated by the arrows.

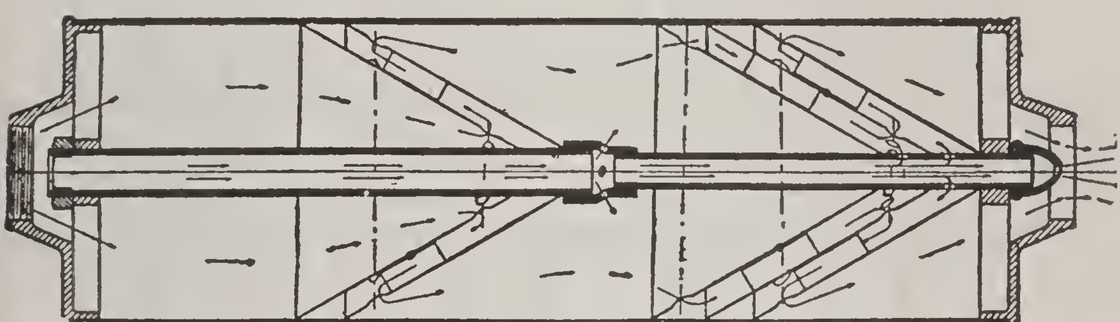


Fig. 135
Ejector Type of Muffler

Fig. 135 shows a longitudinal section of the ejector type of muffler, in which the flow of gas through a nozzle creates a vacuum in the chamber surrounding it. The vacuum space is filled by gas, shunted from the stream that supplies it to the nozzle, and this shunted gas passes through crooked passages before it reaches the nozzle chamber. There are three expansion chambers, which are formed by conical diaphragms perforated on top and bottom alternately. There is an axial tube leading through the device, which is of varying

diameter, and part of the gas entering the muffler passes directly from the axial tube into the center chamber and through the second set of cones before the gas which enters the first chamber has passed through the first set. A portion of the gas is conducted straight through to the nozzle, and hence to the atmosphere, its discharge creating a partial vacuum in the third chamber, developing a suction, which draws the gas out of the third chamber in a uniform stream.

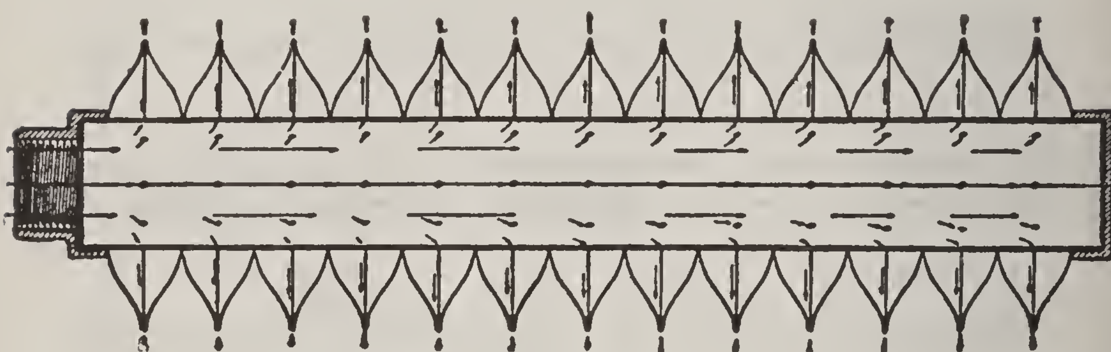


Fig. 136
Radiating Fin Muffler

The muffling effect is obtained by drawing the gas off in a uniform stream and reducing the pressure before the main body of the gas enters the atmosphere. The pressure in the first chamber is higher than that in the second chamber, and the third chamber has a pressure slightly above that of the atmosphere. In this type of muffler the whole of the exhaust gas will pass out before the next exhaust, leaving the pressure in the muffler slightly below that of the atmosphere. The set of cones nearest the outlet prevents the air from rushing in and fill-

ing the muffler, avoiding the necessity of driving the air out ahead of the next exhaust. Thus the exhaust expands in a chamber below atmospheric pressure.

Radiating Fin Muffler. -In a few instances the radiating fin muffler has been used. In this type, shown in Fig. 136, the muffler consists of a pipe, larger than the exhaust pipe leading from the engine, on which are placed a number of truncated cones or saucer-shape discs of metal. The gas escapes from the pipe through holes in the disc, thence into the atmosphere by forcing the edges of the discs apart. The pressure of the gas left in the engine, cylinder, exhaust pipe and muffler will depend on the amount of pressure necessary to force the discs open. They are generally made of copper, which has the advantage of being a good conductor of heat.

Muffler Exits. The final passage of the exhaust from the muffler into the air is accomplished in a number of ways; most mufflers use a tube, sometimes the end of the tube is full size, sometimes it is made smaller but still left round, sometimes it is flattened. In any case, this outlet should be so located that as the charge passes through the muffler it reaches the outlet slowly and in a nearly continuous stream.

Muffler Cut-Outs. Mufflers are generally equipped with muffler cut-outs, which by-pass the gas so that it exhausts direct into the atmosphere with its attendant noise. There are

three reasons why they are so equipped, namely: to tell if the engine is exploding regularly; to clean the exhaust pipe; to have it act as a safety valve in case of explosions in the muffler. If the power of the engine increases when the muffler is cut out, it is a sure sign that the muffler is of defective design or needs cleaning.

MUFFLER CUT-OUT VALVE. One form of cut-out valve is shown in Fig. 137. It is inserted in exhaust pipe P, by sawing a hole in its under

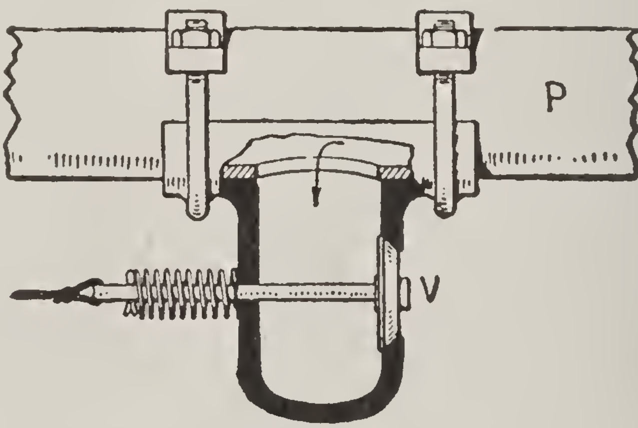


Fig. 137
Muffler Cut-Out Valve

side. The cut-out valve housing clamps to the pipe by a couple of V-clamps. The valve is carried in a cylindrical compartment under the exhaust pipe, and consists of a spring closed poppet valve a little larger in diameter than the internal diameter of the exhaust pipe. It opens against the exhaust pressure to prevent leakage.

CARE OF MUFFLERS. From time to time, all mufflers should be cleaned, because it will be found that they will contain a considerable amount of carbon deposits. These deposits not

only tend to increase the back pressure, but they retain the heat of the exhaust, thus allowing the gases to escape at a higher temperature than they should. A muffler should be taken apart and cleaned once a year, or oftener if there are any indications of loss of power, resultant from back pressure.

Exhaust-valves, Diameter and Lift of. The formulas, and Table No. 1, given for admission-valves, apply also to exhaust-valves. For motors with excessively high speed, the valve diameter given by the formula or table should be increased at least 15 per cent, the formula will then read,

$$D = \frac{B \times S \times R}{13{,}000}$$

where D is the required diameter of the valve opening, B the bore of the cylinder, S the stroke of the piston and R the number of revolutions per minute of the motor.

Exhaust Valve Closure. Some of the loss in efficiency of a gas engine may be caused by the improper closing of the exhaust valve. If it closes too early, an excess of burned gas will remain in the cylinder, while if it is kept open too long some of the burned gas will re-enter the cylinder during the suction stroke. If the exhaust valve area were as large, or nearly as large, as that of the cylinder, there would be no appreciable back pressure, and in this case the exhaust valve would not have to be opened

before the end of the stroke. Since, however, all exhaust passages are restricted in area, the exhaust should be so timed that the loss resulting from an early opening, and the loss arising from too much back pressure should be a minimum.

Expansion—Best Conditions for. The efficiency of the expansion in an engine cylinder depends upon the initial volume of the charge, the condition of the mixture, the compression pressure, the point of ignition, the speed of expansion and the losses due to radiation.

The losses due to improper expansion may therefore be decreased by making large valves and valve passages, but these often mean greater heat losses. The losses due to radiation may be reduced by increasing the temperature of the jacket water, and decreasing the area of the cylinder. But if the cylinder wall temperature is increased, there are considerable difficulties with lubrication, and the increased gain in thermal efficiency will be more than offset by the increased friction.

In order to obtain the highest efficiency the difference in the temperature of the water entering and leaving the cylinder jacket should be a maximum. In practical tests it has been found that the best results are obtained when the jacket water is near the boiling point.

Explosive Motors. Explosive motors are of three forms, known as stationary, marine and automobile. Their general characteristics are

implied by their various designations. The stationary motor may be either vertical or horizontal. Marine motors, designed for application to boats, are almost invariably vertical. Automobile motors are of comparatively recent introduction and of great variety, the aim of the designers being to secure the maximum of power and minimum of weight. They also may be vertical or horizontal.

These three forms may be again divided into two-cycle and four-cycle types. In the former an explosion occurs at every revolution. In the latter there is an explosion at every alternate revolution.

Explosive motors are dependent for successful operation on two things: First, a charge of gas or vapor, mixed with sufficient air to produce an explosive mixture, and second, a method of firing the charge after it has been taken into the combustion chamber of the motor.

When coal gas is used the supply is taken from the main and mixed directly with the necessary proportion of air. When gasoline is used, air is mixed with it in the correct proportion by carbureting devices.

After the charge of gas and air has been taken into the cylinder it is compressed, as will be shown later, by the action of the motor itself and then fired, usually by an electric spark actuated by the motor, but sometimes by the use of a tube screwed into the cylinder and

heated from the outside, the heat, of course, being communicated to the gas. The resulting explosion operates the motor.

The principal parts of a four-cycle explosive motor are the cylinder, the piston, the piston rings which fit into grooves in the piston: two sets of valves, one to admit the charge and the other to permit it to escape after the explosion; a crank shaft and connecting rod which connect it with the piston head, and a flywheel, whose presence insures steady running of the motor, and whose further functions will be better understood as the description proceeds. In the two-cycle form of motor there is really but one valve, the exhaust and admission-ports being covered and uncovered by the piston itself.

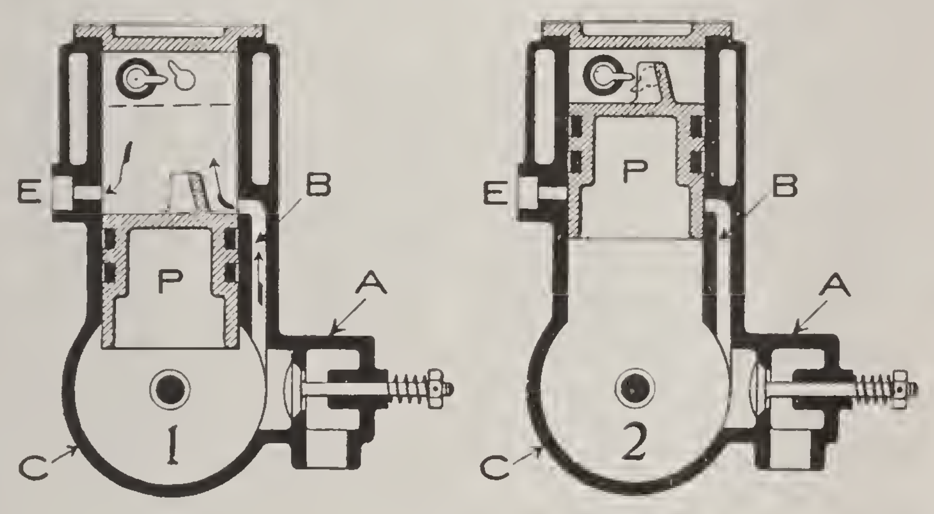
All of the parts referred to are of the motor proper. Other parts, which are separate from the motor but on which its operation depends, are the carbureter, which supplies the charge of gasoline vapor and air for a gasoline motor, or a mixing chamber for mixing air and gas in the case of a gas motor, and the batteries and other parts of the electrical ignition device.

A part which has no connection with the actual running of the motor but with which practically all are fitted is the muffler, whose purpose is to deaden the sound of the explosion.

The cylinders of all except very small motors are as a rule partly encased in a chamber

through which water is circulated, the object of this being to keep the cylinder cool.

TWO-CYCLE MOTOR. The foregoing outline of the functions of the parts of the motor prepares us for a description of the two-cycle form of motor. This particular form of motor draws in a charge of gas or vapor, compresses it, fires it and discharges the product of combustion or burned gases while the crank makes but a sin-



TWO-CYCLE MOTOR DIAGRAM

Fig. 138

gle revolution and while the piston makes one complete travel backward and forward.

Fig. 138 shows two sectional views—that is to say, views of the motor cut in two, longitudinally—of the principal parts of a two-cycle motor. Other parts, such as the crank shaft, connecting rod and flywheel, are omitted to avoid confusion. C is the crank case and A the admission valve, through which the vapor

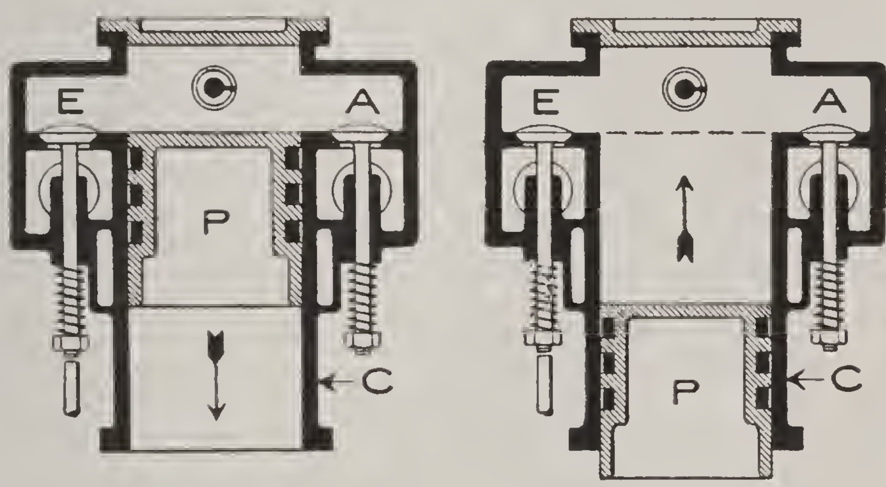
passes to the crank case. B is the inlet passage, through which it passes from the crank chamber to the cylinder. P is the piston. The igniter, which makes the electric spark when the lower point comes in contact with the upper, is shown immediately below the cylinder cover. This causes the explosion of the vapor. E is the exhaust port, through which the burned charge escapes after the piston has been driven outward by the explosion and has reached the end of its stroke.

Let it be supposed that the motor is still and the crank chamber C is full of gas or vapor. To start the motor the piston is started by means of a crank on the flywheel shaft, and as it passes to the position shown in the left-hand drawing it forces the charge of vapor through the port B into the cylinder. The piston then returns to the position shown in the right-hand view, moving away from the crank chamber C, and in doing so closes the port B and the exhaust opening E and compresses the charge of vapor. The points of the igniter come together, a spark occurs and the resulting explosion forces the piston outward again. When the piston reaches a point near the end of the stroke, as shown in the left-hand drawing, it uncovers the port E and the burned charge passes out, the new charge coming through the port B immediately afterwards.

The admission of the new charge to the crank chamber is controlled by the action of the pis-

ton. As the latter travels outward it has a tendency to create a vacuum in the crank chamber. This draws the valve inward and admits the charge of vapor.

It will be observed that there is a projection on the head of the piston. This is generally known as a baffle-plate. Its object is to prevent the incoming charge from passing directly across the cylinder and out at the ex-



FOUR-CYCLE MOTOR DIAGRAM

Fig. 139

haust port E. which, it will be observed, is directly opposite it. The baffle-plate directs the incoming charge toward the combustion chamber end of the cylinder, providing as nearly as may be, a pure charge of vapor and assisting in the expulsion of the remainder of the burned gases remaining in the cylinder as a result of the last explosion.

FOUR-CYCLE MOTOR. Fig. 139 furnishes two

sectional views of a four-cycle type of motor with some of the parts removed, as in Fig. 138. It shows a cylinder C, admission-valve A, a piston P, and exhaust-valve E in place of the exhaust-port E in Fig. 138.

The left-hand view shows the piston P about to suck in a charge of vapor, by the same method as previousy described, through the admission-valve A into the cylinder C. The suction continues until the piston P reaches the position shown in the right-hand view. Then the piston returns until it again arrives at the position shown in the left-hand view, compressing the charge of mixture during this operation. Just before the piston arrives at the end of its travel in this direction, the charge of vapor, now under compression, is ignited by the method previously explained and its expansion forces the piston back to the position shown in the right-hand view. When the piston has, for the second time, reached the position shown in the right-hand drawing, a mechanical device opens the exhaust-valve. The exhaust-valve remains open until the piston has again arrived at the position in the left-hand view. Then it closes, the piston again commences to draw in a charge of vapor and the cycle of operation of the motor is repeated.

Fans for Cooling. Fans used for cooling cylinders are of various designs, most of them having four, five, or six blades. The average speed of revolution is about one and one-half times

the speed of the engine. In some instances fly-wheel fans, similar to the one shown in Fig. 140 are used, in which case they need a tight bonnet, and under pan. In the Lanchester method of air cooling two aluminum fans are

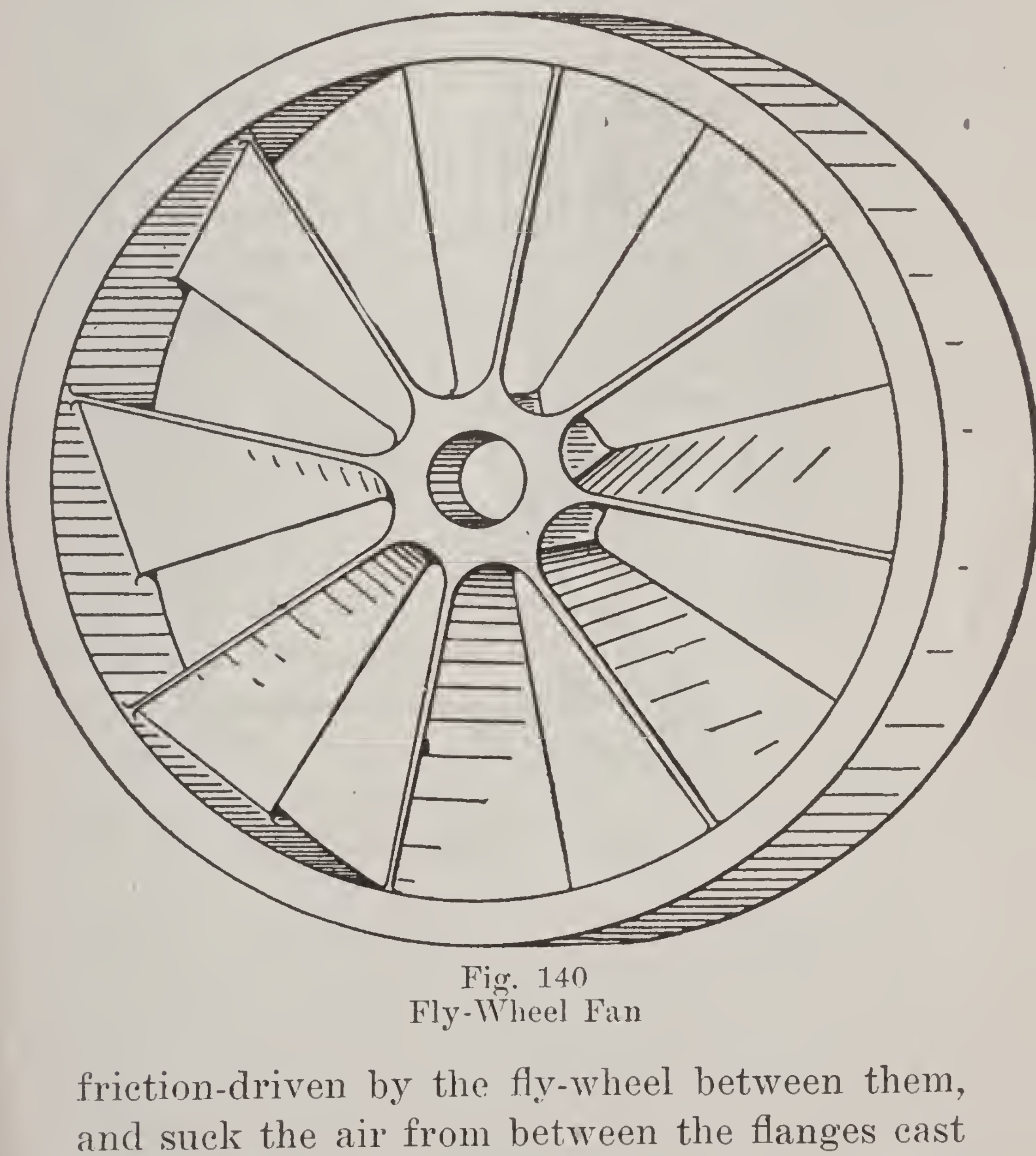


Fig. 140
Fly-Wheel Fan

friction-driven by the fly-wheel between them, and suck the air from between the flanges cast on the two cylinders into the wind chest and thence into the centre of the fans, the air then being ejected by centrifugal force at the per-

iphery. The fans consume but little power, and discharge the heated air quite away from the motor.

Fiber, Vulcanized. Paper-pulp treated with sulphuric acid, washed and afterwards compressed into sheet or rod form, is known as vulcanized fiber.

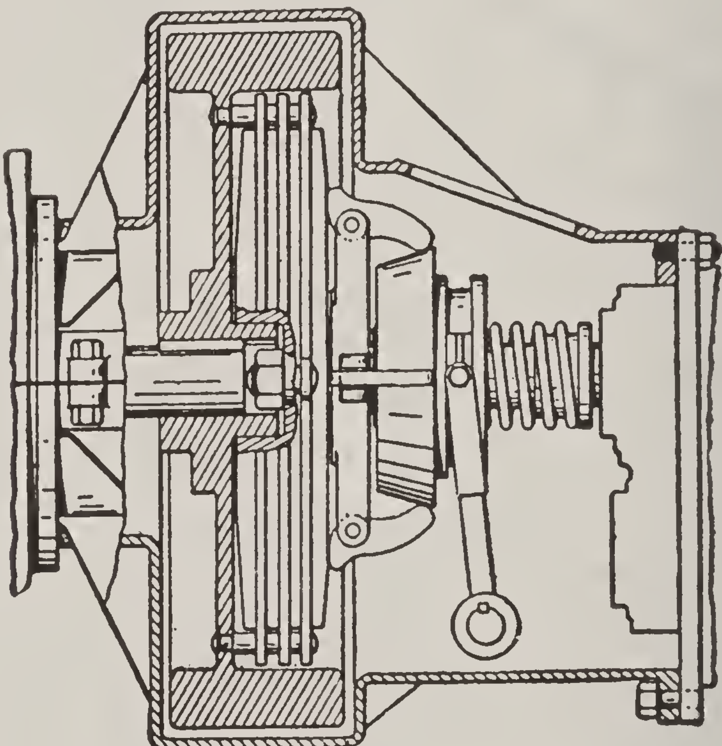


Fig. 141
Five-Plate Clutch

Five-plate Clutch. In the matter of the number of plates in the disc clutch there is no agreement between designers. Some use a very large number of thin plates, as many as fifty or sixty, and others use a very small number, as few as six or eight; in fact, it may be said that the single disc clutch, which has only two frictional surfaces, is the lower limit. One arrangement

which uses five plates is shown in Fig. 141. The diameter of the clutch is somewhat smaller than that of the single or three-plate types, but its diameter must be quite large in order to transmit considerable horse power.

Floating Axle. In a full-floating axle the entire weight of the rear end of the car is carried on the axle housing, or casing, leaving the drive-shafts in the axle with no other work than that of revolving the wheels. In this axle, by the removal of the hub caps, the drive-shaft in each half of the axle can be pulled out, owing to its being free in the housing, and having generally a squared end which fits into the bevel gears of the differential. In a semi-floating rear axle the complete car weight at the rear is carried on the axle housing, identically as in the floating axle, but the drive-shafts of the axle are not removable by pulling endwise through the hub. This is because these shafts are tightly keyed at their inner ends with differentials, bevels or, as is the case in one or two cars, the bevel gear is formed integrally with the shaft.

Fluxes for Soldering. Some good fluxes for soldering purposes are:

Iron or steel	Borax or sal-ammoniac.
Tinned iron	Resin or chloride of zinc.
Copper to iron	Resin.
Iron to zinc	Chloride of zinc.*
Galvanized iron	Mutton tallow or resin.
Copper or brass	Sal-ammoniac or chloride of zinc.
Lead	Mutton tallow.
Block tin	Resin or sweet oil.

*Chloride of zinc is simply zinc dissolved in hydrochloric (muriatic) acid, until the acid is cut or killed.

Flywheels. One of the first and most important considerations in connection with the construction of a gasoline automobile motor is the proper diameter and weight of the flywheel. If the diameter and weight of the flywheel be known, the speed of the motor or its degree of compression will become a variable quantity. On the other hand, if the speed of the motor and the degree of compression be fixed, the diameter or weight of the flywheel rim must be varied to suit the other conditions. If the speed of the motor and its degree of compression be known, the diameter of the flywheel or the weight of the flywheel rim may be readily ascertained from the following formulas.

WEIGHT OF RIMS OF FLYWHEELS. The weight of the rim of the flywheel is the only portion which enters into the following calculations, the weight of the web, or spokes and hub being neglected.

Let M.P be the mean pressure of the compression, and A the area of the cylinder in square inches. If S be the stroke of the piston in inches, and N the number of revolutions per minute of the motor, let D be the outside diameter of the flywheel in inches and W its required weight in pounds, then

$$W = \frac{M.P \times A \times S \times N}{2560 \times D}$$

DIAMETER OF RIMS OF FLYWHEELS. A motor

that is intended to operate at a slow rate of speed, and consequently with a high degree of compression, will require a flywheel of much greater diameter and weight than a high speed motor of the same bore and stroke. It may be well to remember that within certain limitations the diameter and weight of a flywheel should be as small as is possible, as an increase in either means a reduction in motor speed, and a consequent loss of power.

To ascertain the diameter of a flywheel when all other conditions are known, if D be the required diameter of the flywheel in inches, then

$$D = \frac{M.P \times A \times S \times N}{2560 \times W}$$

Weight of Rims of Flywheels with a Given Fluctuation in Speed. If it be desired to run a motor at a practically uniform speed and with only a slight fluctuation or variation in the velocity of the flywheel, if W be the required weight of the flywheel and **x** be the allowable fluctuation of the flywheel in revolutions per minute above and below its normal speed, then

$$W = \frac{M.P \times A \times S \times N}{365 \times \mathbf{x}}$$

Horsepower Stored in Rims of Flywheels. It is sometimes desirable to know the amount of

energy or horsepower which may be stored in the rim of a flywheel of known diameter and weight, with a given speed. If H.P be the horsepower stored in the rim of the flywheel, then

$$H.P = \frac{D^2 \times W \times N}{792{,}000}$$

Safe Speed for Rims of Flywheels. The safe velocity for the rim of a cast iron wheel is taken at 80 feet per second. Let N be safe speed of the flywheel in revolutions per minute, then

$$N = \frac{18{,}335}{D}$$

The mean pressures corresponding to varying degrees of compression may be found by reference to Table 2.

M.P = Mean pressure.

A = Area of cylinder in square inches.

S = Stroke of piston in inches.

N = Number of revolutions per minute.

D = Diameter of flywheel in inches.

W = Weight of flywheel in pounds.

Balancing with the Reciprocating Parts of the Motor. The flywheel should be balanced as accurately as is possible before mounting on the crank shaft. In the first place set the crank shaft on two perfectly straight parallel bars. one bar under each end. Then attach the

connecting rod and piston to the crank and turn the shaft until the crank jaws are parallel with the floor or in other words at right angles to a perpendicular line drawn through the center of the shaft. Place a scale under the crank pin, or use a hanging scale attached to some rigid support above the pin and connect it to

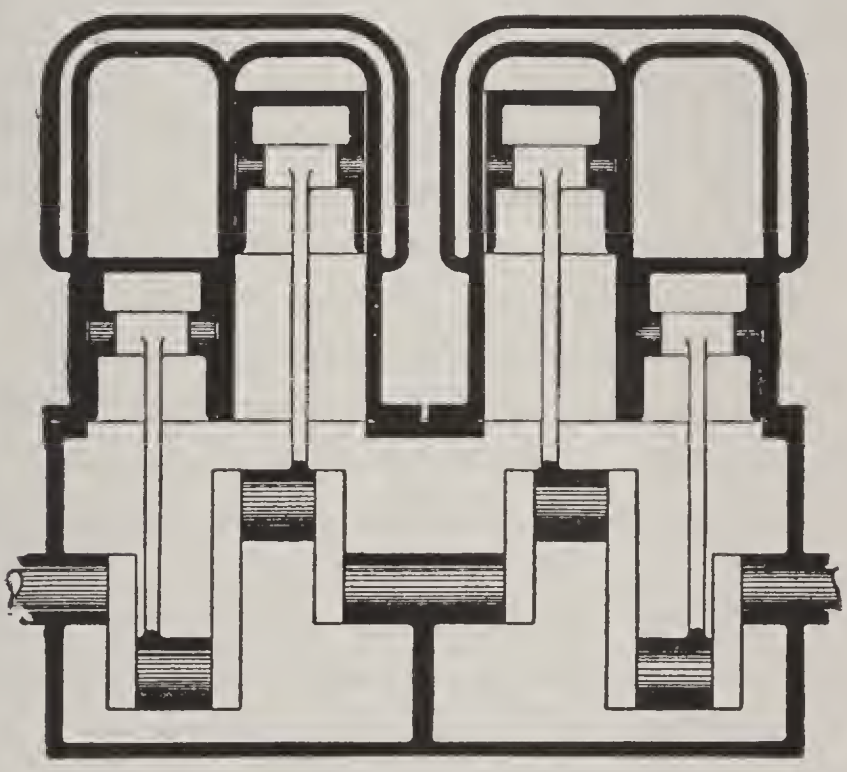


Fig. 142
Four-Cylinder Engine

the crank pin by a wire or cord sufficiently strong to carry the weight. Then find the weight of the parts according to the scale and attach the same amount to the flywheel at the same distance from the shaft on the side opposite the crank, and the result will be a fairly balanced motor. It is impossible to obtain a perfect balance, but the above method will as-

sist greatly in reducing the vibration of the motor.

Four-cycle Motor, Operation of. A four-cycle motor has only one working stroke or impulse for each two revolutions. During these two revolutions which complete the cycle of the motor, six operations are performed:

1. Admission of an explosive charge of gas, or gasoline vapor and air to the motor-cylinder.
2. Compression of the explosive charge.
3. Ignition of the compressed charge by a hot tube, or an electric spark.
4. Explosion or extremely sudden rise in the pressure of the compressed charge, from the increase in temperature after ignition.
5. Expansion of the burning charge during the working stroke of the motor-piston.
6. Exhaust or expulsion of the burned gases from the motor-cylinder.

Four-Cylinder Engines. Fig. 142 is an outline view of a four cylinder gasoline engine, showing the position of the pistons and cranks relative to each other. In this type of motor the cylinders are generally placed side by side as shown in Fig. 142, although some forms of runabouts use the four cylinder opposed setting. In the four cylinder engine each piston is at all times one stroke behind its predecessor; as for instance, when explosion occurs behind piston 1, piston 2 is compressing, piston 3 is drawing in its charge, and the expanded gas is being exhausted from behind piston 4. The

development of power is therefore continuous, there being at all times one piston on the working stroke. In a four cylinder engine there are always two pistons moving in one direction, while the other two are moving in the opposite direction. This uniformity of movement prevents shock, and the motor may be made very light in proportion to power capacity. The majority of automobiles are equipped with this type of engine.

Frame—Sagged, How to Straighten. A frame which is sagged to the extent of permanent deformation can be restored to approximate straightness by heating it in a charcoal fire with an air blast. To do this properly it will most likely be necessary to cut out the rivets, so the side members can be handled independently. A good plan of procedure is to inclose the bent portion of the frame in a section of stove pipe of sufficient size in which the charcoal fire is built. A length of 1-inch gas pipe, closed at one end and having 5/16-inch holes, drilled at intervals of about 6 inches, is laid in the bottom of the pipe and furnishes the air supply from a bellows. When the charcoal fire is well kindled, the frame is introduced upside down and is supported at the ends. The fire is then concentrated on the bent portion, and as the frame becomes hot it will straighten itself. It must be watched carefully and the air blast stopped as soon as the frame is seen to be straight. Most of the frames used in Amer-

ican cars are ordinary carbon steel and require no special treatment. It will be well, however, on stopping the air blast to shift the stove pipe to a cooler portion of the frame, to permit the

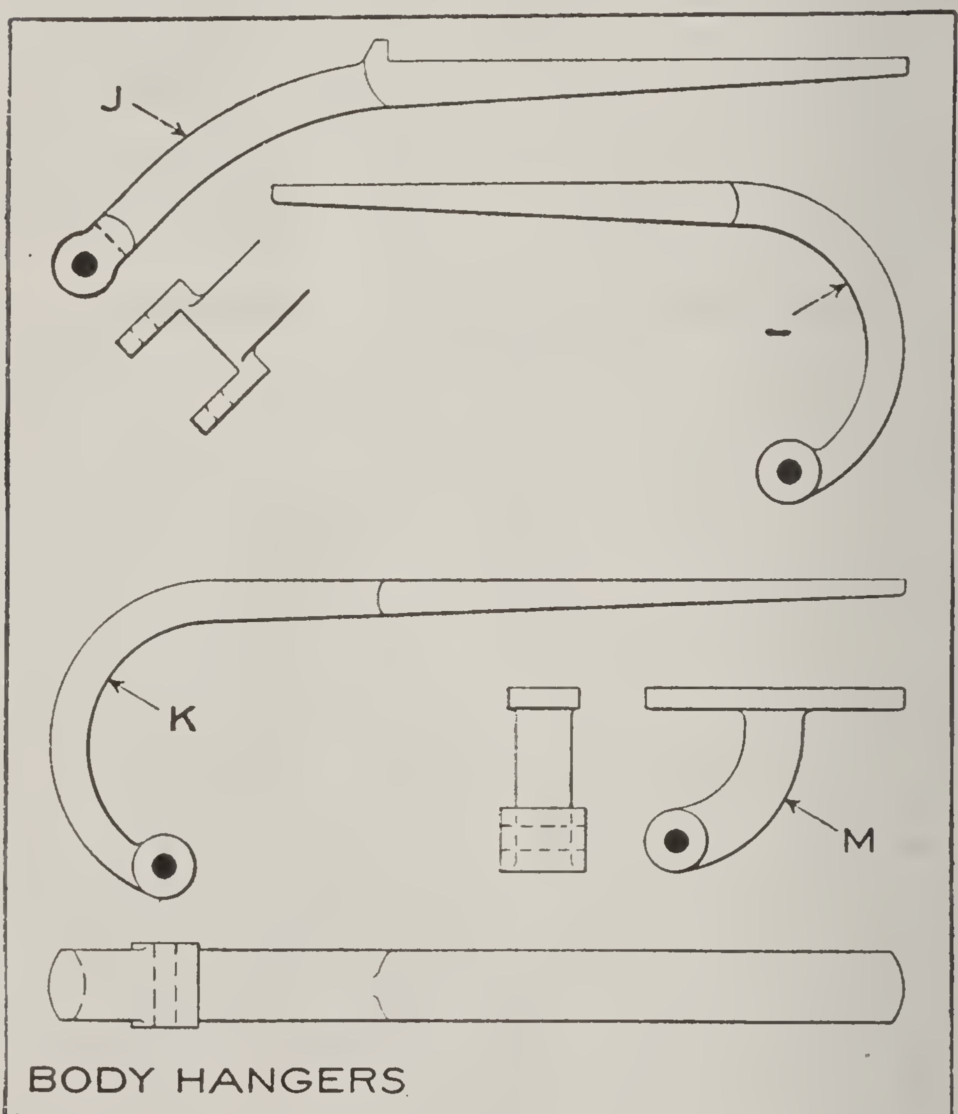


Fig. 143

part which has been straightened to cool as quickly as exposure to the air will permit. A frame which has been sagged and straightened in this manner will require to be trussed to prevent recurrence of the trouble. As conditions

vary so much the best rule to follow is to observe the truss arrangement on some similar car. The struts should be about 4 or 5 inches long, and should be located at the spots where the sagging has occurred. The truss rod itself should be about ½ inch in diameter, and drawn taut by a turnbuckle, which may be finally tightened when the chassis has been assembled.

Frame Hangers. Since the inception of the automobile, the frame or running gear of the car is in nearly all cases attached to the springs and the body carried upon the frame. The parts, or in some cases actually extensions of the frame are, or should be properly termed frame-hangers, but they are erroneously and almost universally known as body-hangers, from the term applied to the constructions used in horse-drawn vehicles. Some forms of frame-hangers are of pressed steel construction, but the usual forms are made of drop-forgings. Figure 143 shows some of the forms of drop-forged frame-hangers for automobile use: The front or what is generally known as the pump-handle form of hanger is shown at J, the rear or fish-hook form is shown at K and the forms of hangers used for attaching the inner ends of the springs to the frame are shown at L and M.

Franklin Carbureter. The Franklin Carbureter is of the float feed type. The supply of gasoline is controlled by a T handle connected with the valve, and passing to the dash within

easy reach of the operator. There is also a primer attached, to be used in starting.

The throttle, and by pass valves work together, and thus insure a perfect mixture of gasoline and air at all times. The working of these valves, the securing of the correct amount of warm air, and the entire absence of springs, result in a uniformity of work under varying conditions.

Friction. Friction, being the resistance to motion of two bodies in contact, depends upon the following laws: It will vary in proportion to the pressure on the surfaces; it increases with the roughness of the surface; friction of rest is greater than friction of motion; the total friction is independent of the area of the contact surfaces when the pressure and speed remain constant; and friction is greater between soft bodies than hard ones.

The behavior of lubricated surfaces is quite different from dry ones, the laws of fluid friction being independent of the pressure between the surfaces in contact, but it is proportional to the density of the fluid and in some manner to the viscosity. When a bearing is thoroughly lubricated it does not seem to make much difference what the metals are, because there is a layer of oil running around with the journal and sliding over another layer adhering to the bearing. If, however, the feed fails, or the pressure gets too heavy for the nature of the lubricant, and so squeezes it out, or the temperature

has risen so high as to affect the body of the oil, then the surfaces come into contact and the peculiar nature of the contact asserts itself, some combinations abrading and seizing more readily than others. When the lubrication is thorough, the condition of the fluid friction being realized, the intensity of the load makes less difference than would be expected.

Friction Drive. For power transmission under conditions where the load is constant and uniform the friction drive shows a high efficiency, but such conditions do not as a rule exist with the automobile. Where the slip exceeds 4 per cent, the drive falls off considerably in efficiency, and as the conditions of service in automobile work are about the worst imaginable it would appear to be difficult to prevent this. The load is never constant for any length of time, and it is about as far from being uniform as it possibly can be. Still the friction drive has proven considerable of a success on a number of light cars, and the experience of the manufacturers of the latter would seem to show that even under such very adverse circumstances as the necessity for pulling a car out of a hole, or starting from dead on a very steep hill, the friction drive has been able to acquit itself with credit.

Fuels for Automobiles. Apart from the possibility of an increase in the fuel resources of the world due to some revolutionary discovery, the ingredients in any mixed fuel for automo-

bile use must be confined to the following list, in which, for completeness, gasoline is included:

Gasoline. Average composition, C=84, H=16.

Source, petroleum.

Boiling point, 50° to 150° Cent.

Specific gravity, .680 to .720.

Calorific value, 19,000 B. T. U.

Latent heat, small.

Benzine. Average composition, C=92, H=8.

Source, coal tar.

Boiling point, 80° Cent.

Freezing point, 5° Cent.

Specific gravity, .899.

Calorific value, 19,000 B. T. U.

Latent heat, small.

Alcohol. Average composition, C=32, H=8, O=35.

Source, vegetable matter, principally corn, beets, potatoes, sugar cane.

Boiling point, 70° Cent.

Specific gravity, .806.

Calorific value, 12,600 B. T. U.

Latent heat, considerable.

Tar Benzol. Average composition, C=92, H=8.

Source, a by-product in the manufacture of coke.

Boiling point, 80° to 120° Cent.

Specific gravity, .895.

Calorific value, 19,000 B. T. U.

Latent heat, small.

Kerosene. Average composition, C=85, H=15.

Source, petroleum.

Boiling point, 150° to 300° Cent.

Specific gravity, .800 to .825.

Calorific value, 19,000 B. T. U.

Latent heat, considerable.

Motor Spirit, Naphtha, Benzoline, Benzine. Average compositnon, C=85, H=15.

Source, petroleum and shale.

Boiling point, 60° to 160° Cent.

Specific gravity, .750.

Calorific value, 19,000 B. T. U.

Latent heat, appreciable.

Methyl Alcohol, Wood Spirit, Naphtha. Average composition. C=38, H=12, O=50.

Source, the distillation of wood.

Boiling point, 66° Cent.

Specific gravity, .812.

Calorific value, 9,600 B. T. U.

Latent heat, appreciable.

Acetylene Ethene. Average composition, C=92, H=8.

Calorific value, 25,000 B. T. U.

Fuel Consumption of a Two-Cycle Motor. The two-cycle engine uses more fuel than the four-cycle. The greater consumption is not so much due to the fact that the two-cycle motor makes an explosion for every revolution, in contrast with the missed stroke of the four-cy-

cle, as it is to the fact that there is considerable retention in the cylinder of the exhaust charge, and that, despite the deflector, more or less of the fresh charge escapes at the exhaust. The two-cycle is also harder on a battery owing to the greater frequency of the demands upon it, but with improved methods of ignition, even dry batteries have been found to give very satisfactory service.

G. and A. Carbureter. This carbureter has no springs, but has a separate float chamber, and a peculiar form of ball valve for an extra air supply.

The air passage is a Venturi tube, resembling the hour glass in shape. Air enters through the screened lower end, and gasoline is admitted through an angling pipe at the small diameter center, there being no needle valve in the nozzle. The size of the nozzle is mathematically calculated in proportion to the capacity of the motor, as is also the size of the Venturi shaped air passage. To the top of the air passage is secured a drum portion, in which is a rotating throttle. Interposed between the top of the Venturi tube, and the throttle chamber there is an expansion in the bottom of which is a series of holes of various sizes, and resting in each is a metal ball. These balls being of different weights it follows that, when a sufficient supply of air cannot enter through the Venturi tube, the pull of air will lift, first the lighter

balls, and as this pull increases the heavier balls will be raised.

The Gaeth Carbureter. The Gaeth Carbureter is of the separate float chamber type, and the mixing chamber is a vertical cylinder through the center, which is completely filled by a needle valve which turns when the engine is throttled. All the air comes up from below and passes around the needle. At the base of the needle are V shaped openings, which regulate the admission of the air. In the side of the needle are openings for controlling the passage of the outgoing mixture, a partial turn of the needle also affecting a part movement of the needle valve in the nozzle, so that with no air there is an increased flow of gasoline.

This carbureter may be set for slow running, and needs no other advancement for high speeds. The device is controlled in three ways.

First—by the entering air.

Second—by the entering gasoline.

Third—by the mixture passing to the motor, all being under control of the driver by means of a lever at the top of the starting wheel.

Garage—Cleaning Floors. A hot saturated solution of common washing soda will do very well. This can be made up in quantities and stored against future use. If this method is used, be sure to reheat it before using, the boiling point being about right. Since that will be too hot to apply with the hands, use any old broom or brush to "slosh" it around on the

floor. An equally good, if not better, solution to use for this purpose is trisulphate of sodium, marketed by several chemical companies, and sold at from four to five cents per pound at retail. This can be used cold and will not injure the most delicate hands; on the other hand, it will clean them very thoroughly, so that users of this solution use it for the hands as well as for the floors. This is strong, however, and may be used to remove paint.

Protection From Fire. The recommendations of the National Fire Protection Association pertaining to garages and their operation are as follows: No dynamo or gas engine should be permitted where gasoline is stored or handled; all exposed lights should be eliminated; cleaning of acetylene lamps and removal or renewing of carbide should be carried on outside of garage; the residue of acetylene lamps should never be cast on the floor; machines should have oil tanks emptied before being put in the repair shop; the use of extension electric wires is condemned, as they may cause fire; motor testing should be done outside, for sparks might ignite the fumes of gasoline; storage tanks should be filled from outside of garage; all volatile oils should be stored in good, heavy tanks under ground, as far away from the building as possible; pipes for filling storage tanks should not pass through the garage in any way; a filling station should be twenty to thirty feet from the entrance to the garage, and

tanks of cars filled from there if it is necessary to fill them when the cars are inside of the garage; furthermore, the station should be fireproof, and all cars should be brought to this point for filling; smoking and carrying of

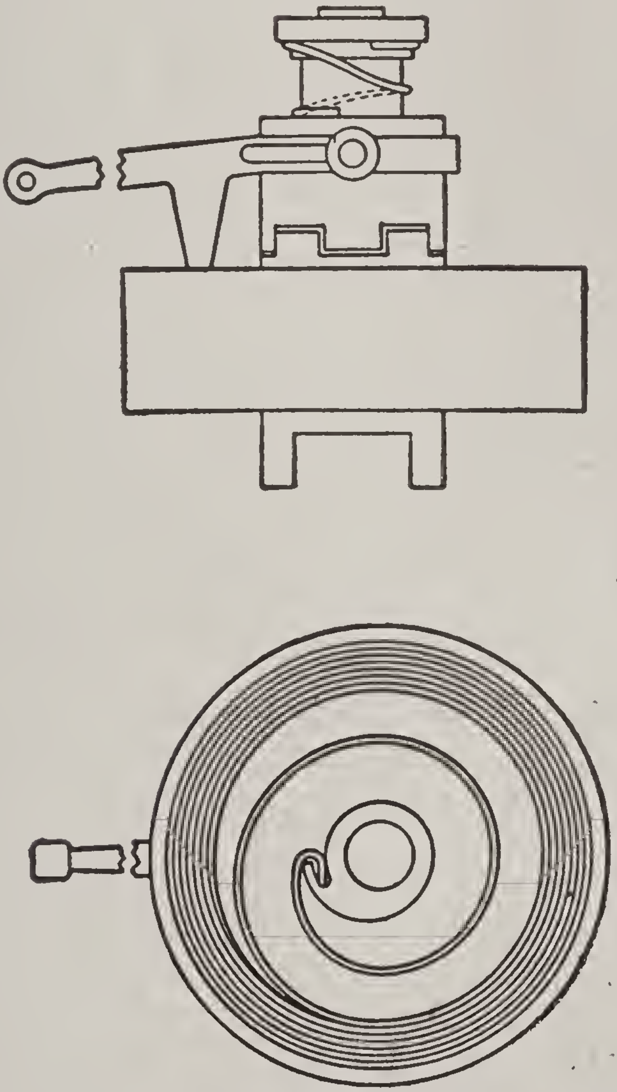


Fig. 144
Gardner Self-Starter

matches, or use thereof should be strictly prohibited; floors should be kept free of oil drippings, and pails of sand should be kept handy in proximity to gasoline.

Gardner Magneto Self-starter. An automobile fitted with this device can be started from

the seat by pushing a pedal or button. As shown in Fig. 144, it consists of four parts, all of which are attached to the transmission shaft. The arrangement consists of a spiral spring, which is wound by the momentum of the car when the car is running, and this tension is available the next time the car needs to be started. By pushing a pedal a clutch is actuated, which releases the spring and causes the engine shaft to be revolved fifteen or twenty turns, which is more than sufficient to fill the cylinders with gas and create sufficient magneto voltage to give a good spark.

Gases, Expansion of. All gases expand equally, 1/273 part of their volume for each degree of temperature, Centigrade, or 1/491 part of their volume for each degree of temperature, Fahrenheit.

Gas Producer for Automobiles. Homogeneity is a property which is difficult of attainment in mixtures of gasoline and air out of a carbureter of the conventional float-feed type, unless the gasoline is volatile in the extreme, and this is not likely to be true if the gasoline is a mechanical mixture of a number of the fractional distillates due to the range of temperature, in the distilling process, which is said to obtain at the present time. It is claimed that the present practice in the production of gasoline is to use all the fractions between 50 and 150 deg. C.

Hexane, the formula of which is C_6H_{14}, is ad-

mitted to be the superior fraction of all the distillates from the crude oil used in the production of gasoline, and while the distillers would like to have credit for using nothing but the best for the purpose, the fact remains that gasoline of the present time can scarcely be classed as hexane, nor does it seem to hold any more hexane than the amount required to assist in cranking a cold motor, it being the case that a motor could not be started "cold" in the absence of some of the more volatile of the hydrocarbons.

Carbon in Cylinders Due to Gasoline Used. Lubricating oil is charged with the crime of depositing carbon on the surfaces of the combustion chamber, and this carbon in turn causes "bucking," and pre-ignition. It probably is true that inferior cylinder lubricating oil will deposit carbon, to some extent, but the main trouble is from the gasoline which will not vaporize until it is allowed to contact with the hot cylinder walls, and this process of reducing the gasoline to vapor is bound to lead to a carbon deposit for the same reason that wood is "coked" if it is heated to a temperature of about 650 deg. C., provided the amount of air present is less than that which would cause complete combustion.

To a very considerable extent the trouble is aborted by preheating the mixture on its way to the combustion chamber, or if the air is heated sufficiently before it enters the carbu-

reter. The time was when this process worked very well, indeed, but it is becoming more difficult every day to so heat the air, or the mixture, that globules of gasoline will not enter the cylinders and coke up. The amount of heat required for the purpose is vastly more than is generally well understood, and unless enough heat is supplied, the result will be a crop of carbon in the combustion chamber.

Any process that will manufacture a homogeneous gas to the entire exclusion of liquid gasoline will serve the purpose, and preheating the mixture is a step in the right direction. The time was when autoists hoped that illuminating gas could be put under compression and that enough of it could be carried in a tank of reasonable size to accomplish the work. It is generally understood that illuminating gas will serve well for the purpose, but it is not possible to store enough of the gas to enable a car to travel far without having to replenish the tank.

That the gas-tank idea clings to the automobile with a tenacity which augurs for inherent utility will be seen in the illustrations here offered. Fig. 144a shows a gas tank and the manner in which it is connected up to a six-cylinder car in which it will be noticed that the carbureter is entirely dispensed with. The entire absence of a carbureter is the best indication of the change over from liquid gasoline to gas, and it is the manufacture of this gas, as it

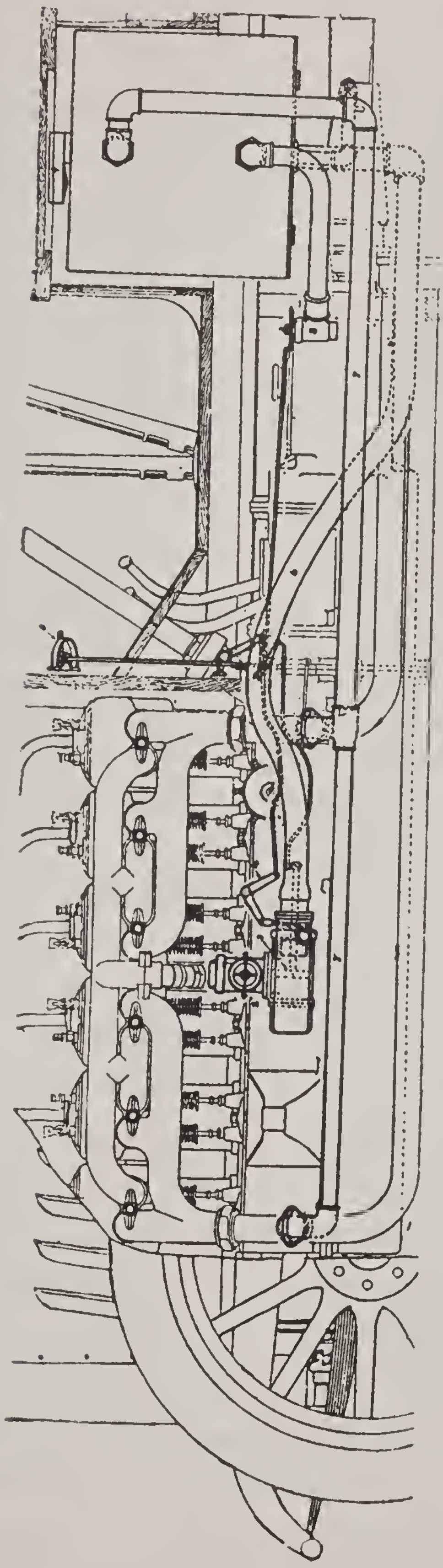


Fig. 144a
Diagrammatic Scheme Showing the Manner in Which the Generator is Used and Piping Connecting to Motor

is needed for the motor, that will be given attention at this time.

The gas producer consists essentially of a copper tank, or container, about the size of the conventional gasoline tank; located in any convenient place, as under the seat of the driver, which tank is filled with laminæ of wood-pulp sheets, superimposed. Each sheet is about ¼ inch thick, of rectangular shape, and drilled full of holes, each about ¼ inch in diameter, and spaced about 1½ inches apart. The sheets of wood pulp are separated from each other about the thickness of one of the laminæ, and the nests of sheets are in two sections.

Between the two sections of the nests of wood-pulp sheets the space is taken by a heater for the air as it enters on its way to the gasoline-saturated wood-pulp sheets. The heater is made up of a coil of piping in a manner not unlike the radiators used in steam-heating work. The exhaust gases from the motor serve to convey the heat to the radiator. The air enters at the top, passes through the heater coil to the under side of the nests of wood-pulp boards. The admission of air through a check valve, and the suction of the motor, furnishes the required difference in air pressure, so that the air is sucked in.

Since the air cannot turn back through the check valve, it must pass up through the nest of pulp boards, and the holes in the boards furnish the openings, as well as a large surface.

Fig. 145 shows the top of the container cut away, exposing the top layer of pulp boards to view, and the small holes will be noticed. The same figure shows the heater in the middle of the container, and Fig. 146 is offered to more clearly bring out the construction features of the system. The cross section of the container,

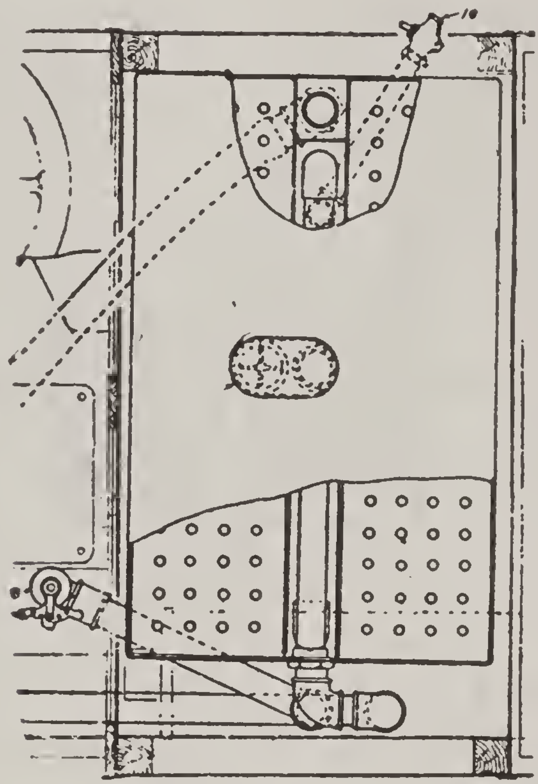


Fig. 145
Generator with Top Cut Away to Show Holes in Pulp Filling

as shown in Fig. 146, indicates that there is but very little free space in the same, and in the process the gasoline is spilled into the top of the tank in sufficient quantity to saturate the wood-pulp mass.

The quantity of gasoline required is about 60 per cent of the amount that the tank would

hold, provided the wood pulp were not present. Excess gasoline is not required, and in the process, the heated air as it passes up through the holes in the pulp boards wipes vapor of gasoline off of the surfaces, and owing to the heated condition of the air, it is in condition to become enriched, even if the gasoline is of poor

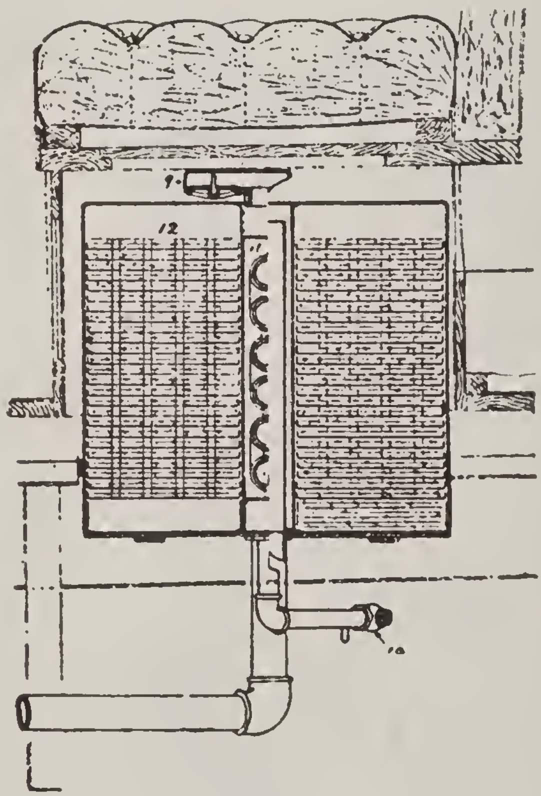


Fig. 146
Section Showing Nest of Boards with Spaces Between.

quality. By means of a valve designed for the purpose the rich mixture is diluted after it leaves the tank, and the motor is enabled to draw the mixture of homogeneous gas suited for its needs, while the driver is enabled to alter the proportions at will, according to road conditions, atmospheric influences, and properties of the gasoline, as the supply reduces

in the tank, leaving the heavier residuum. There can be no explosion of the gas in the tank for the reason that the gas is not sufficiently diluted with air to render it explosive.

Gasoline, How Obtained. Benzine, Gasoline, Kerosene and the kindred hydro-carbons are products of crude petroleum.

They are separated from the crude oil by a process of distillation. The process is very similar to that of generating steam from water.

Crude petroleum subjected to heat will give off in the form of vapor such products as Benzine, Gasoline and Kerosene, etc. The degrees of heat at which these products are separated are comparatively low. Various degrees of heat will separate the distinct products. As a means of illustration, it may be said that the crude oil when raised to certain temperatures gives off vapors which when cooled liquefy into what are known as Benzine, Gasoline and Kerosene.

Viscosity of Gasoline. It is a mistake to assume that because gasoline does not thicken up, it is retarded in its flow through the nozzle of the carbureter. Taking gasoline having a specific gravity of 0.71 the quantity that will pass through the nozzle of a carbureter under a given pressure will increase as the temperature is increased, as shown in the following table:

Temp. degrees F.	Relative Flow.
50°	1
59°	1.073
68°	1.145
77°	1.212
86°	1.27
95°	1.335

Since carbureter nozzles are not readily adjustable, nor with any degree of certainty, it follows from the above that the influence of temperature upon the weight of fuel ejected will most certainly affect the efficiency of the carbureter. This source of trouble goes to indicate that some means of maintaining a constant temperature is of the greatest advantage, and in a measure it argues for the adaptation of water (hot) jacketing, not around the depression chamber, as is usually the practice, but around the gasoline (float) bowl, in order to maintain a constant temperature of the liquid gasoline as it flows through the nozzle.

Gasoline Explosions. There are two entirely different kinds of explosion, which would undoubtedly both be referred to as gasoline explosions. The real gasoline explosion is the kind taking place in the cylinder of a gasoline motor, in which heat and pressure are suddenly produced by the combustion of gasoline vapor in air. The other kind of explosion referred to may be explained as follows:

If a tank of gasoline be placed on a woodpile and the latter set on fire, the heat would raise a pressure in the tank, which would rapidly increase and the tank would finally explode from the pressure. The gasoline would then be thrown in all directions, and, owing to its superheated condition, the greater part of it at least would instantly vaporize, mix with the

air of the atmosphere and be ignited by the flame which caused the explosion.

Gasoline Fires, Extinguishing. A number of fires have been caused by leaky gasoline pipes on automobiles, and many persons would like to know of chemicals which can be used to put out such fires. Water is exceedingly dangerous to use, and it is not always possible to get at the fire to smother it with wet rags or waste.

In case of fire due to gasoline, use fine earth, flour or sand on top of the burning liquid.

A dry powder can be used for this purpose which will extinguish the fire in a few seconds. It is made as follows: Common salt, 15 parts—sal-ammoniac, 15 parts—bicarbonate of soda, 20 parts. The ingredients should be thoroughly mixed together and passed through a fine mesh sieve to secure a homogeneous mixture.

If by any chance a tank of gasoline takes fire at a small outlet or leak, run to the tank and not away from it, and either blow or pat the flame out. Never put water on burning gasoline or oil, the gasoline or oil will float on top of the water and the flames spread much more rapidly.

Several gallons of ammonia, thrown in the room with such force as to break the bottles which contain it, will soon smother the strongest fire if the room be kept closed.

Gasoline Motor Construction. When designing a gasoline automobile motor, the first question that will arise is as to the proper number

of cylinders. The question as to the proper number of cylinders for an explosive motor may be briefly summed up as follows: A single cylinder has the merit of simplicity, and requires less mechanism to operate it, but tends towards excessive vibration. Multi-cylinders develop more power with less weight and reduce the motor vibration and strain, and have also other advantages over a single cylinder. The question therefore is: How many cylinders are best in practice? To give the best results, a two-cylinder motor should, if the cranks are opposed, have its cylinders in axial alignment in order to ensure a uniform impulse. If the cranks and cylinders are opposed it is possible to obtain correct mechanical balance of connecting rods and pistons, and vibration is thus diminished. If the cylinders are of the twin form with the cranks opposed, explosions will necessarily follow each other at a half revolution, and one and a half revolutions apart. This gives irregular impulses which tend to set up vibration. The next best construction is three cylinders, with the cylinders parallel, and the cranks set at an angle of 120 degrees. This gives regular impulses two-thirds of a revolution apart, and consequently a more uniform strain on the parts, and reduces vibration.

A four-cylinder motor has greater advantages of mechanical balance than the three-cylinder form. but on the other hand, by reason of the greater amount of exposed cylinder wall

for a given capacity, it is not as economical in fuel consumption. The greater advantage of four as compared with the three cylinders, is a greater division of the impulses, reducing vibration to a minimum.

Other points to be considered in the design of a motor are:

The proper arrangement or location of all working parts so as to be readily accessible for repair or adjustment.

Practically automatic lubrication of the motor.

The best and simplest method of operating the admission and exhaust-valves.

The proper diameter and weight of flywheel, and a practically correct balance of the reciprocating parts of the motor.

The best and most reliable system of ignition, with a view to eliminating ignition troubles.

The most economical type of carbureter, and one that will require the least attention.

And last, but not least, reduction of weight, simplicity of construction and good mechanical design.

In the construction of motor cylinders experience has clearly established one point—that the cylinder, with its combustion and valve-chambers, should be integral or in one piece, and that no joints closed by gaskets should exist back of the head of the piston. While all manufacturers do not adhere to this rule, it is a fact that many difficulties have been experi-

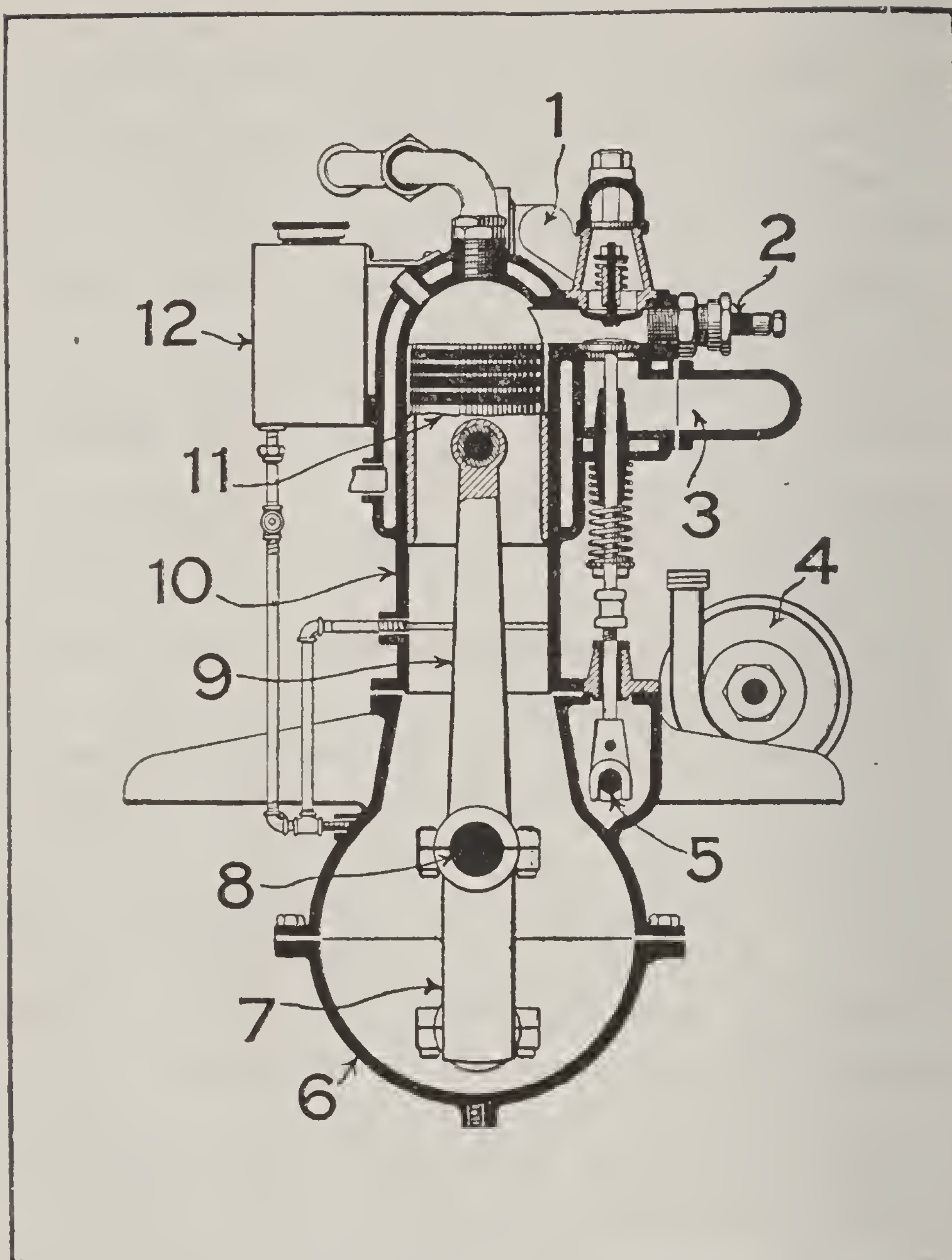


Fig. 147
Vertical Cylinder, Water-Cooled Gasoline Motor

1. Admission valve.
2. Spark plug.
3. Exhaust valve.
4. Rotary pump.
5. Cam shaft.
6. Crank case.
7. Crank shaft.
8. Crank pin.
9. Connecting rod.
10. Cylinder.
11. Piston and rings.
12. Oil tank.

enced with leaky joints, and that the plan of avoiding them altogether should be followed.

Figure 147 shows a vertical cross-section of a gasoline automobile motor of the most approved modern type. It has automatic lubrication, detachable inlet or admission-valve and rotary pump for the water circulating system.

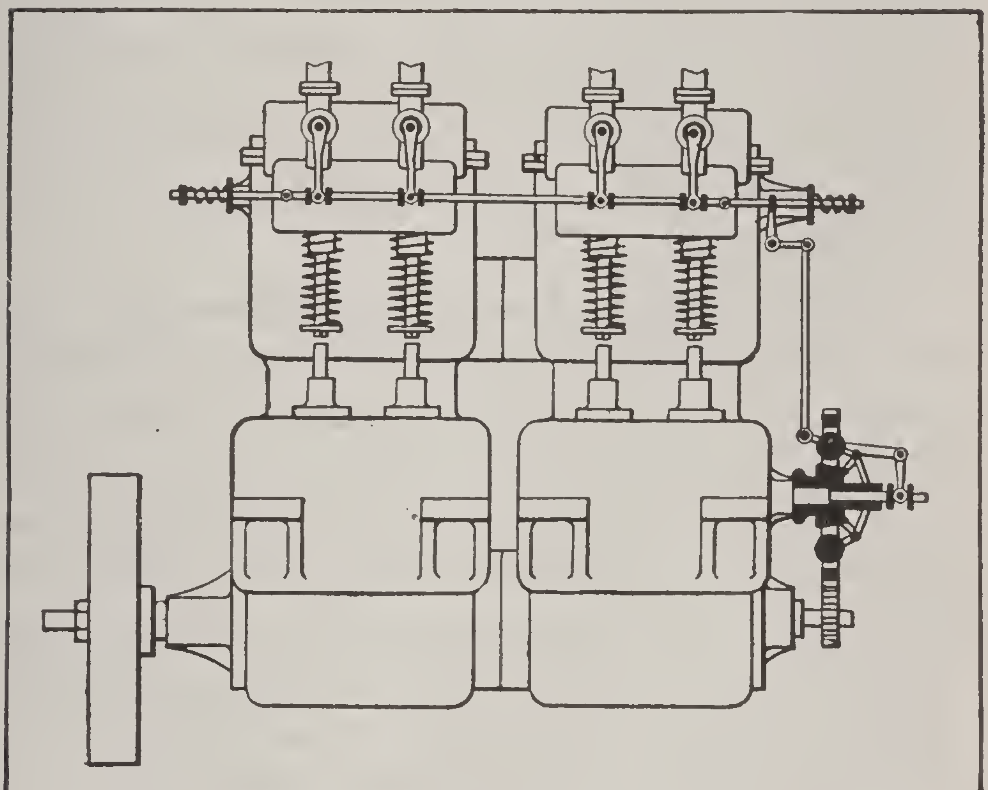


Fig. 148
Vertical Four-Cylinder Motor
With Mechanically Operated Admission-Valves With Automatic Throttling Governor

Figure 148 illustrates a modern type of vertical four-cylinder gasoline automobile motor, having the admission-valves automatically throttled by means of a centrifugal governor on the end of the cam-shaft, as shown in the

drawing. The admission-valves are mechanically operated.

While the cooling of the cylinder of an explosive motor is most successfully accomplished by means of a water-circulating system, a number of up-to-date cars successfully use cooling devices other than water. The success of air cooling for explosive motors is due in most cases to the use of a number of ribs cast integral with the cylinder and having a large radiating surface.

Gasoline Motor, Fuel Consumption of. The fuel consumption of a motor is always a serious question, and one of importance to the purchaser as well as to the manufacturer.

Ordinarily about one and two-tenths pints of gasoline per horsepower hour under full load will cover the fuel consumption. That is, when the mixture is of the proper explosive quality and the water comes from the jacket at a temperature of about 160 degrees Fahrenheit.

The temperature of the water in the jacket around the cylinder has a great deal to do with the fuel consumption.

If the water is forced around the cylinder so as to keep it cold, the heat from the combustion is cooled down so quickly by radiation that the expansive force of the burning gases is materially reduced, and consequently less power is given up by the motor.

The object of the water is not to keep the cylinder cold, but simply cool enough to prevent

the lubricating oil from burning. The hotter the cylinder with effective lubrication the more power the motor will develop.

It should be remembered that a hot motor is the most economical in fuel.

Gasoline, Thermo-dynamic Properties of Gasoline and Air. The following table, 11, gives the thermo-dynamic properties of gasoline and air, and may be of interest, in view of the fact that information on this subject is sparse, and most of that only theoretical, or empirical deductions.

This table gives the explosive force in pounds per square inch of mixtures of gasoline vapor and air, varying from 1 to 13 down to 1 to 4, also the lapse of time between the point of ignition and the highest pressure in pounds per square inch attained by the expanding charge of mixture. The tests from which the results given were obtained, were made with a charge of mixture at atmospheric pressure, so as to more accurately note the results, as the mixture takes much longer after ignition to attain its highest pressure, and is slower also in expanding.

It may be well to remember that there are no more heat-units, and consequently no more foot-pounds of work in a mixture of gasoline and air, under 5 atmospheres compression, than under 1 atmosphere compression.

Flanged or ribbed air-cooled motors will approach the figures given in the table for the

initial explosive force for the varying compressions, very closely, while thermal-siphon water-cooled motors will come within about 20 per cent of these results, and pump and radiating coil cooled motors will come within about 30 per cent. While it appears at the first glance that the proper thing to do to get the greatest efficiency from a motor would be to let it run as hot as possible, experience has shown that the repair bill of a hot motor will more than offset its efficiency over the cooler water-jacketed motor, with pump and radiating coils. The last two columns in the table give the temperature of the burning gases, the first of the two columns the actual temperature with the accompanying mixture of gasoline and air, and the second the theoretical temperatures, or temperature to which the burning mixture should attain, if there were no heat losses.

TABLE 11.

THERMO-DYNAMIC PROPERTIES OF GASOLINE AND AIR.

Gasoline, Vapor and Air.	Time in Seconds between Ignition and Highest Pressure.*	Explosive Force in Pounds per sq. in. Compression in Atmospheres.			Temperature of Combustion in Degrees Fahrenheit.*	
		3	4	5	Actual.	Theoretical.
1 to 13	0.28	156	208	260	1857	3542
1 to 11	0.18	183	244	305	2196	4010
1 to 9	0.13	234	312	390	2803	4806
1 to 7	0.07	261	348	435	3119	6001
1 to 5	0.05	270	360	450	3226	6854
1 to 4	0.07	240	320	400	2965	5517

*At atmospheric pressure.

Gear—Changing. In changing gears the autoist should endeavor to have the motor and car moving at nearly corresponding rates of speed before the clutch is engaged. With the planetary type of gear, changing is simple, and drivers usually guess at the proper period at which to make the change, any mistake in estimating the rates of the car and motor being of little consequence, as the bands will slip instead of transmitting the shock to the gear. A similar action occurs in the case of individual clutch or friction gears, but with the sliding type severe strains and shocks have to be taken up by the clutch, and are usually transmitted in part to the gear if the clutch is not slipped. What applies to the sliding type in general applies to the other types as well.

In changing from a lower to a higher gear it will be necessary to speed up the motor by means of the throttle or accelerator in order to store enough energy in the flywheel to furnish the work needed to accelerate the car to its new speed. As the speed of the car increases the higher gear should be engaged, the autoist not being in too great a hurry to make the change. The movement of the change gear lever should be made quickly in order that the car does not lose way. When changing from a higher to a lower gear the change should be made as quickly as possible before the car has time to slow down. When climbing a steep hill it should be ascended as far as possible on the

high gear by proper use of the throttle and spark, and the change down to the lower gear made as soon as the motor begins to labor or is in danger of stopping. The presence of an unusual number of passengers in the car will affect its ability to negotiate grades which ordinarily are taken on the high gear, and the autoist should remember this and not attempt to force the car to travel on that gear with the increased load, but resort to a lower gear.

Gear Case and Rear Axle. It is a familiar fact that the gear case requires to be periodically emptied of oil, and the accumulated metal grit washed out before fresh oil is supplied. The same is true of the rear live axle casing, except that the gears in the axle do not clash and therefore do not wear out as fast as the change speed gears. At least once in a season the oil in the rear axle should be drained out, a liberal supply of kerosene introduced, and the axle jacked up while the engine is run to agitate the oil and wash out the differential, etc.

Gears, Diametrical Pitch System of. Table 12 gives the necessary dimensions for laying out and cutting involute tooth spur gears from No. 16 to No. 1 diametral pitch. Formulas are also given so that if the number of teeth and the diametral pitch are known, the pitch diameter can be ascertained—also, the diametral pitch, outside diameter, number of teeth, working depth, and clearance at bottom of tooth:

P = Pitch diameter in inches.
D = Diametral pitch.
W = Working depth of tooth in inches.
T = Thickness of tooth in inches.
O = Outside diameter in inches.
C = Circular pitch in inches.

(1) $$\text{Pitch diameter} = \frac{T}{D}$$

(2) $$\text{Outside diameter} = P + \frac{2}{D}$$

(3) $$\text{Diametral pitch} = \frac{T}{P}$$

(4) $$\text{Circular pitch} = \frac{3.142}{D}$$

(5) $$\text{Working depth of tooth} = \frac{2}{D} = 2 \div D$$

(6) $$\text{Number of teeth} = P \times D$$

(7) $$\text{Thickness of tooth} = 1.571 \times D$$

(8) $$\text{Clearance at bottom of tooth} = \frac{C}{20}$$

For example: Required, the pitch diameter of a gear with 20 teeth and No. 5 diametral

pitch. From Formula No. 1, as the pitch diameter is equal to the number of teeth divided by the diametral pitch, then 20 divided by 5 equals 4, as the required pitch diameter in inches.

What is the outside diameter of the same gear? From Formla No. 2, as the pitch diameter is 4 inches, and the diametral pitch No. 5, then 4 plus 2/5 equals 4 2/5 as the proper outside diameter for the gear.

What would be the diametral pitch of a gear with 30 teeth and 5 inches pitch diameter? From Formula No. 3, 30 divided by 5 equals 6, as the diametral pitch to be used for the gear. In this manner by the use of the proper formula any desired dimension may be obtained.

TABLE 12.

DIMENSIONS OF INVOLUTE TOOTH SPUR GEARS.

Diametral Pitch.	Circular Pitch.	Width of Tooth on Pitch Line.	Working Depth of Tooth.	Actual Depth of Tooth.	Clearance at Bottom of Tooth
1	3.142	1.571	2.000	2.157	0.157
2	1.571	0.785	1.000	1.078	0.078
3	1.047	0.524	0.667	0.719	0.052
4	0.785	0.393	0.500	0.539	0.039
5	0.628	0.314	0.400	0.431	0.031
6	0.524	0.262	0.333	0.360	0.026
7	0.447	0.224	0.286	0.308	0.022
8	0.393	0.196	0.250	0.270	0.019
10	0.314	0.157	0.200	0.216	0.016
12	0.262	0.131	0.167	0.180	0.013
14	0.224	0.112	0.143	0.154	0.011
16	0.196	0.098	0.125	0.135	0.009

Gears, Horsepower Transmitted by. The following formulas will give the horsepower that

may be transmtited by gears with cut teeth of involute form and of various metals.

H.P = Horsepower.
P = Pitch diameter in inches.
C = Circular pitch in inches.*
F = Width of face in inches.
R = Revolutions per minute.

$$H.P = \frac{P \times C \times F \times R}{90} \quad \text{(Annealed tool steel.)} \quad (1)$$

$$H.P = \frac{P \times C \times F \times R}{140} \quad \text{(Mach. steel or Phosphor Bronze.)} \quad (2)$$

$$H.P = \frac{P \times C \times F \times R}{410} \quad \text{(Cast Brass.)} \quad (3)$$

$$H.P = \frac{P \times C \times F \times R}{550} \quad \text{(Cast Iron.)} \quad (4)$$

Example: Required, the horsepower which a tool steel pinion, 2 inches pitch diameter, 1 inch face and No. 10 diametral pitch, will transmit at 900 revolutions per minute.

Answer: From the table the circular pitch corresponding to No. 10 diametral pitch is

---

*The circular pitch corresponding to any diametral pitch number, may be found by dividing the constant 3.1416 by the diametral pitch.

Example: What is the circular pitch in inches corresponding to No. 6 diametral pitch.

Answer: The result of dividing 3.1416 by 6 gives 0.524 inches as the required circular pitch.

0.314. Then by Formula No. 1, $2 \times 0.314 \times 1 \times 900$ equals 565.2. This, divided by 90, gives 5.29 horsepower.

Gear, Internal-Epicyclic. It is often desired to ascertain the speed of rotation of the different members of this form of gearing. To calculate their speeds, the following formulas are given, which, by reference to the letters desig-

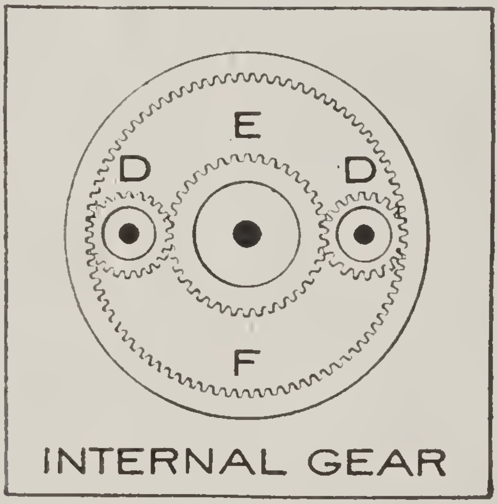


Fig. 149

nating the different parts in Figure 149, may be readily solved.

Let R be the revolutions per minute of the disk or spider carrying the pinions D.

Let N be revolutions per minute of the gear E.

Let G be the revolutions per minute of the internal gear F.

When the internal gear F is locked and gear E rotating, the speed in revolutions per minute of the disk or spider carrying the pinions D is

$$R = N \frac{E}{E + F}$$

If the internal gear be locked and the spider carrying the pinions D be rotated, then the speed in revolutions per minute for the gear E will be

$$N = R \frac{E + F}{E}$$

If the spider carrying the pinions D be held rigid and the gear E be rotated, the speed in revolutions per minute for the internal gear F is

$$G = \frac{N \times E}{F}$$

If the pitch diameter of the gears is not readily obtainable, the number of teeth in each gear may be used instead, as the result will be exactly the same.

Generator. This term is usually applied to any form of chemical or mechanical device which can be used to produce a current of electricity. Mechanical generators of electricity used for ignition purposes are of two forms, dynamos or magnetos. The former is self-exciting by means of coils of wire wound upon the magnet limbs. The latter has permanent magnets instead of coils of wire to induce the current in the armature of the magneto. Mag-

netos, on account of their simplicity of construction and low first cost, are more generally used for ignition purposes than dynamos. They may be operated by the motor with a friction-pulley, gear or belt. Figure 150 shows one form of a magneto arranged to be operated by the friction pulley on the left-hand end of the armature shaft.

The simplest form of magneto and the one shown in Figure 150 consists of two or more

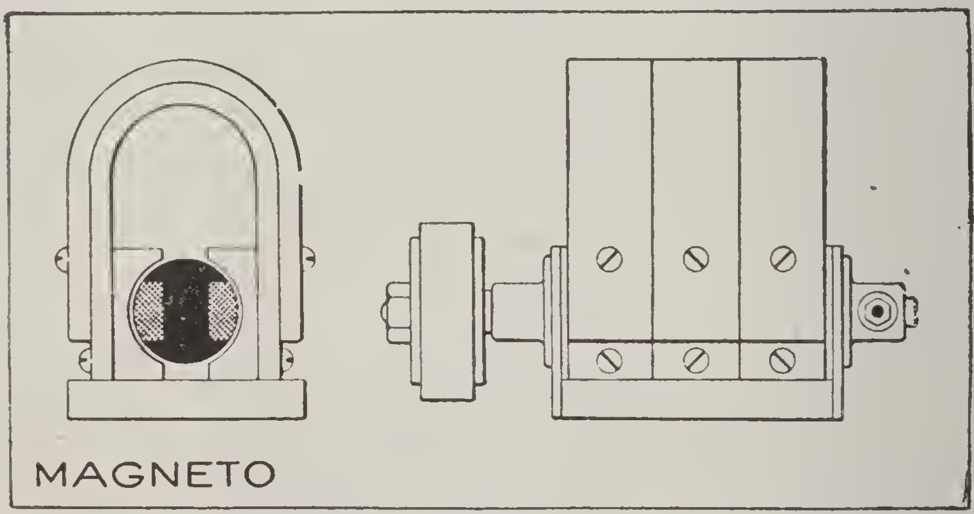


Fig. 150

magnets of horse-shoe shape, the ends of which embrace the pole-pieces, between which rotates a shuttle armature wound with small insulated copper wire. Rotation of the armature of the magneto tends to disturb the path of the lines of force or magnetic flux flowing between the ends of the permanent magnets, which in turn set up powerful induced currents in the armature. The current produced by the magneto is of an alternating nature, but is converted into a

direct or continuous current by means of the commutator on the armature shaft.

Generator—Gas. The gas used in gas lamps is generated by water, in minute quantities, dropping on acetylene (carbide of calcium); the gas thus formed passes from the generating chamber into the body of the lamp and is consumed at the lava tips, which are placed in front of a highly polished mirror. The generators in some cases are separated from the lamp itself and placed on the dashboard, or under the hood, a rubber hose conveying the gas to the lamp.

The interior of the carbide chamber or basket being more or less in contact with the water distribution apparatus, the parts of both apparatus are liable to clogging by the formation of lime residue in the generation of gas. If this residue is allowed to collect, it will have to be removed with a chisel, which is a ticklish operation in a light construction like that of a generator, especially around the water valve or its outlet. Acids are sometimes used to remove the deposit, but as they eat the metal, their use should be prohibited. The basket and pot should be thoroughly washed out after each run with water, the water outlets being cleaned with special brushes, when these are obtainable, or by wires, removing all traces of lime. The water valve should be scraped and tested to see whether it seats properly, care being taken not to damage the valve or its seat in so

doing. While the valve is dismounted for cleaning it would be well to see that its stem is straight, and that it works with some ease in the threaded portion attached to the water chamber. The gas valves should be cleaned and should seat snugly, so that there will be no leakage past them. This applies also to the gas valves on the lamps.

The best position for the generator is on the running-board just back of the change-gear quadrant, and sufficiently far out from the frame to allow a free circulation of air all around it. The generator will keep cool in this position and will perform its work to the best advantage when properly cooled.

Governor, Use of. All explosive motors when running under a heavy load, slow down, or reduce their speed very materially. If the load be entirely or partially removed from the motor very suddenly, it will tend to race. This racing, which causes excessive wear and vibration, is very injurious to the motor. On light cars with small-powered motors, racing is usually prevented by some form of hand control, such as retarding the ignition or throttling the mixture supply. On heavy, high-powered automobiles, racing of the motor is eliminated by the use of some form of centrifugal governor, which controls the motor-speed by one of the three following methods: Retarding the ignition—Throttling the supply of mixture—Preventing the exhaust-valve from opening.

Figure 151 shows a form of governor which operates by preventing the exhaust-valve from opening. When the speed of the motor passes its normal limit, the balls A of the governor move out towards the periphery of the gear or wheel which carries them, causing the cam B to be moved to the right by the action of the dogs on the governor arms, which engage in a grooved collar on the sleeve C.

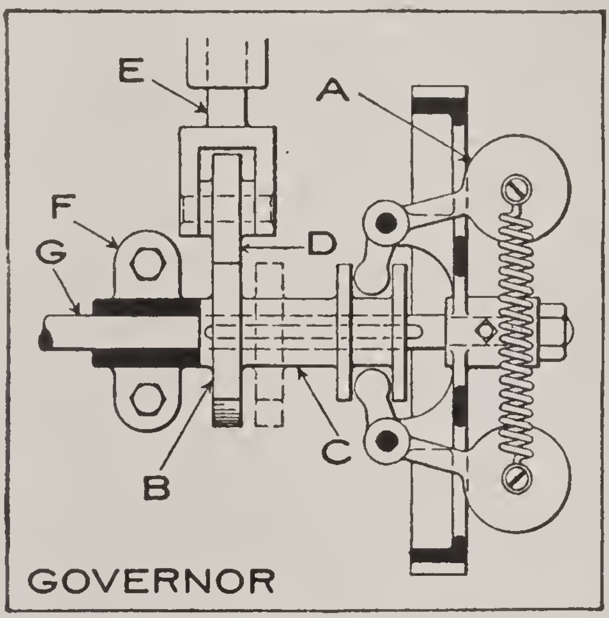


Fig. 151

The nose of the cam B is thus kept out of engagement with the roller D until the motor resumes its normal speed, thus preventing the valve-lifter from opening the valve.

Normally the cam is held in positon by the springs attached to the governor balls, against the shoulder of the bearing F, which carries the cam-shaft G.

On some types of cars the "hydraulic" type

of governor is used. The Packard car, for instance, uses this type. It consists of a circular chamber divided in the middle by a flexible diaphragm, one side being filled with water and connected with the pump and with the cylinders. On the side of the diaphragm, opposite the water, is a large piston, the stem of which projects through the guide and bearing, and is connected with the throttle. As the motor is speeded up, the velocity of the water from the

TABLE 13.

HORSEPOWER REQUIRED TO MOVE A VEHICLE WEIGHING 1,000 POUNDS.

Per Cent of Grade.	Speed in Miles per Hour												
	6	8	10	12	14	16	18	20	22	24	26	28	30
5	1.3	1.7	2.1	2.6	3.0	3.4	3.8	4.3	4.8	5.2	5.6	6.0	6.5
6	1.4	1.9	2.4	2.9	3.3	3.8	4.3	4.8	5.3	5.8	6.3	6.7	7.2
8	1.8	2.3	2.9	3.5	4.1	4.7	5.3	5.8	6.4	7.0	7.6	8.2	8.7
10	2.1	2.7	3.5	4.2	4.8	5.5	6.2	6.9	7.6	8.4	9.0	9.6	10.4
12	2.4	3.2	4.0	4.8	5.6	6.4	7.2	8.0	8.8	9.6	10.4	11.2	12.0
14	2.8	3.6	4.5	5.4	6.3	7.2	8.1	9.0	10.0	10.8	11.7	12.6	13.5
16	3.1	4.1	5.0	6.1	7.1	8.1	9.1	10.1	11.1	12.3	13.1	14.1	15.1
18	3.4	4.5	5.5	6.7	7.8	9.0	10.1	11.0	12.1	13.5	14.5	15.6	16.5
20	3.7	4.9	6.1	7.4	8.6	9.8	11.1	12.2	13.5	14.8	15.9	17.2	18.3

pump is increased and this acts against the diaphragm, moving the piston and tending to close the throttle. As the motor speed decreases the water pressure is lessened and the throttle tends to open.

If left to itself, the Packard governor will hold the motor very closely and uniformly to any speed for which the throttle may be set by the sector lever on the steering wheel.

Grades—Power Required to Climb. Table 13

gives the approximate horsepower required to move a vehicle with a total load of 1,000 pounds, at varying speeds.

Graphite for Cylinder Lubrication. Flake graphite has been used as a lubricant for cylinders of gasoline engines in many cases. It could be used in the proportion of a scant teaspoonful to a pint of oil. This mixture may be introduced into the crankcase by removing the side plate or by pouring it down the vent tube. Some users introduce the graphite direct to the cylinders through the sparkplug hole, or the opening for the make-and-break parts, using an insect gun quill with rubber tube attached. When the latter method is used the quill is filled by inserting it into the graphite, followed by blowing through the rubber tube, when the graphite will be discharged into the cylinder.

In every case the accumulation of too much graphite on the plugs should be prevented, but a small amount does little, if any harm, especially if there are gas currents that will clean it off. On any engine lubricated with ordinary oil, which will run for a long time without sooting its plugs, graphite may be used to advantage, and the plugs will soot little if any quicker.

Heat of Combustion. The quantity of heat generated by the complete combustion of various gases and petroleum products is known as the heat value of the fuel, and represents the maximum amount of heat that can be obtained from a given quantity of the fuel. No accurate

rule has yet been devised by which to compute the heat value of any chemical compound from its formula and the heat values of the elements of which it is composed. Hence, the heat values of compounds must be found by a separate determination for each one in the laboratory. The heat developed by the combustion of some of the commoner fuels and gases is given in Table 14. In the case of carbon, the heat developed by its complete combustion, forming CO_2, and the heat of its partial combustion to CO, are given; also the heat of combustion of CO to CO_2.

Heat Value of a Mixture. The heat value of a mixture may be found from the heat values of the substances of which it is composed and the percentage of each substance. If h_1, h_2, h_3, etc., represent the heat values of the substances forming the mixture, and p_1, p_2, p_3, etc. represent the percentage of each substance, the heat value of the mixture will be represented by the following formula:

$$hm = p_1h_1 + p_2h_2 + p_3h_3 + \text{etc.}$$

Example.—A certain gas has the following composition:

Constituents of Gas	Per Cent.
Hydrogen, H	20
Marsh gas, CH_4	70
Acetylene, C_2H_2	10

What is the heat value per cubic foot of the mixture?

Solution.—Referring to Table 14, the heat

TABLE 14.

MIXTURES OF AIR AND GASES, AND RESULTING HEAT OF COMBUSTION.

Fuel	Chemical Proportions	Weight of Gas at 30°, per Cubic Foot — Pound	Volume of 1 Pound of Gas at Atmospheric Pressure — Cubic Feet		Volume Required to Burn 1 Cubic Foot of Gas — Cubic Feet		Weight Required to Burn 1 Pound of Gas — Pounds		Specific Heat of Gas at Constant Pressure	Heat of Combustion	
			32°	62°	O	Air	O	Air		B. T. U. per Pound of Fuel	B. T. U. per Cubic Foot of Gas at 62°
Oxygen, O	23 lb.O + 77 lb.N = 100 lb. air	.08927	11.20	11.88	...	.....	....	.....	.21751	......	.....
Nitrogen, N	21 vol.O + 79 vol.N = 100 vol. air	.07847	12.77	13.55	...	.....	....	.....	.24380	......	.....
Hydrogen, H	$2H + O = H_2O$	.00562	178.80	189.80	.5	2.38	8.00	34.80	3.40900	62,000	327
Carbon, C	$C + O = CO$	......	......	......	...	.....	....	.....	....	4,400	.....
Carbon, C	$C + 2O = CO_2$	......	......	......	...	.....	....	.....	....	14,600	.....
Carbon monoxide, CO	$CO + O = CO_2$	.07704	12.77	13.55	.5	2.38	.57	2.48	.24790	4,385	324
Carbon dioxide, CO_2	1 lb.C + 2.66 lb.O = 3.66 lb.CO_2	.12323	8.12	8.60	...	.....	....	.....	.21700	......	.....
Methane (marsh gas), CH_4	$CH_4 + 4O = 2H_2O + CO_2$	.04538	22.37	23.73	2.0	9.52	4.00	17.40	.59290	23,976	1,010
Ethylene (olefiant gas), C_2H_4	$C_2H_4 + 6O = 2H_2O + 2CO_2$	.07830	12.77	13.55	3.0	14.28	3.43	14.90	.40400	21,476	1,585
Ethane, C_2H_6	$C_2H_6 + 7O = 3H_2O + 2CO_2$	.08369	11.94	12.67	3.5	16.66	....	.....	....	22,356	1,765
Benzol vapors, C_6H_6	$C_6H_6 + 15O = 3H_2O + 6CO_2$	.22363	4.47	4.74	7.5	35.7	....	.....	.37540	18,183	3,836
Acetylene, C_2H_2	$C_2H_2 + 5O = H_2O + 2CO_2$	.07251	13.79	14.63	2.5	11.9	....	.....	....	21,421	1,464

values per cubic foot of these gases are seen to be 327, 1,010 and 1,464 B. T. U., respectively. Apply the formula just given. $p_1 = .20$, $p_2 = .70$, and $p_3 = .10$. Also, $h_1 = 327$, $h_2 = 1{,}010$, and $h_3 = 1{,}464$. Substituting, $hm = .20 \times 327 + .70 \times 1{,}010 + .10 \times 1{,}464 = 65.4 + 707 + 146.4 = 918.8$ B. T. U. Ans.

TEMPERATURE OF COMBUSTION. The theoretical temperature of the combustion of a given fuel can easily be calculated. Making no allowance for losses of heat, and supposing that just enough air is furnished for the combustion, burning carbon should have a temperature about 4,940° above zero; while burning hydrogen should have a temperature about 5,800° above zero. In practice, these temperatures are never attained, on account of heat losses.

LOSS OF HEAT. The loss of heat from any hot object is accomplished in three ways: by convection, by conduction and by radiation. In all practical cases a body loses heat by a combination of these processes.

When heat is produced in the cylinder by the combustion of the gases, the piston is at or near the upper dead center; that is, it remains nearly stationary when the heat is greatest and when the heat loss per unit area of inclosing walls is most rapid.

Under the usual conditions of ignition, the gas contained in the cylinder must be set into violent motion by the spread of the flame through it, and this motion will aid the dissipa-

tion of the heat in the gas to the containing walls. So convection will be an important factor in the process and perhaps the principal factor. Perhaps a part of the gain in power which has resulted, in some instances, from the use of multiple ignition may be due to violent motion of the gas. Practically all air cooled motors have their valves in the head, so the

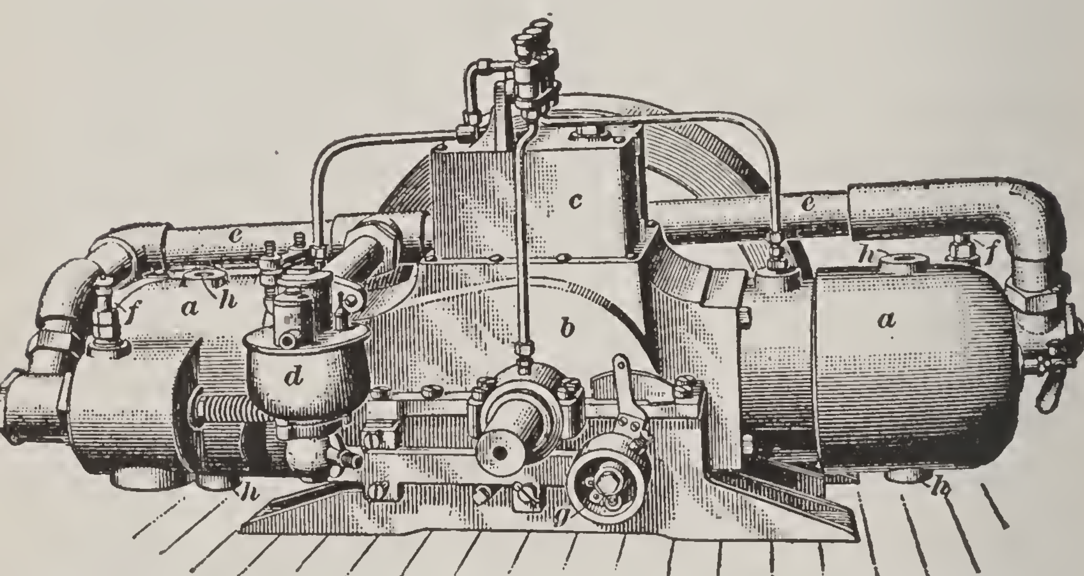


Fig. 152

charge is contained between the cylinder walls and the piston head.

The heat absorbed by the water-jacket is equal to the weight of water passed through the jacket multiplied by the temperature range; or, in other words, it is the difference between the temperature of the water when it enters the water-jacket and that of the water when it leaves the jacket. For instance, if the temperature of the entering water is 50° and that of escaping water is 180°, the temperature range

is 180° — 50° = 130°. Then, if the weight of the water passing through the jacket in 1 hour is 100 pounds, the heat carried away is 100 × 130 = 13,000 British thermal units.

Horizontal Engines. Fig. 152 shows a view, and Fig. 153 a longitudinal section of a horizontal two cylinder opposed motor. Referring to Fig. 152, the cylinders a, a, are bolted to a common crank case b, on the cover of which is mounted a mechanical lubricator c, for lubricating the pistons and bearings. Connection between carbureter d, in which the fuel is vaporized, and the inlet valve chambers of the two cylinders is made by the supply pipe e. The charge is ignited by the spark plugs f, f, the time of the spark being controlled by means of the timer g. The cooling-water connections to both cylinders are made at h, h.

Reference to the sectional view, Fig. 153, shows how the cylinders a are arranged with reference to each other and to the crankcase b, the offset in the cylinders necessitating an offset in the connecting rods c, which are attached to cranks 180° apart. By thus setting the cranks and arranging the cylinders in opposition, the crankshaft d receives a power impulse at each revolution, with no gap or uneven interval in the time of the impulse. The explosive mixture enters the cylinders through automatic inlet valves e, the burned gases passing out through the exhaust valves f mechanically operated by means of the two-to-one gears g and h, the

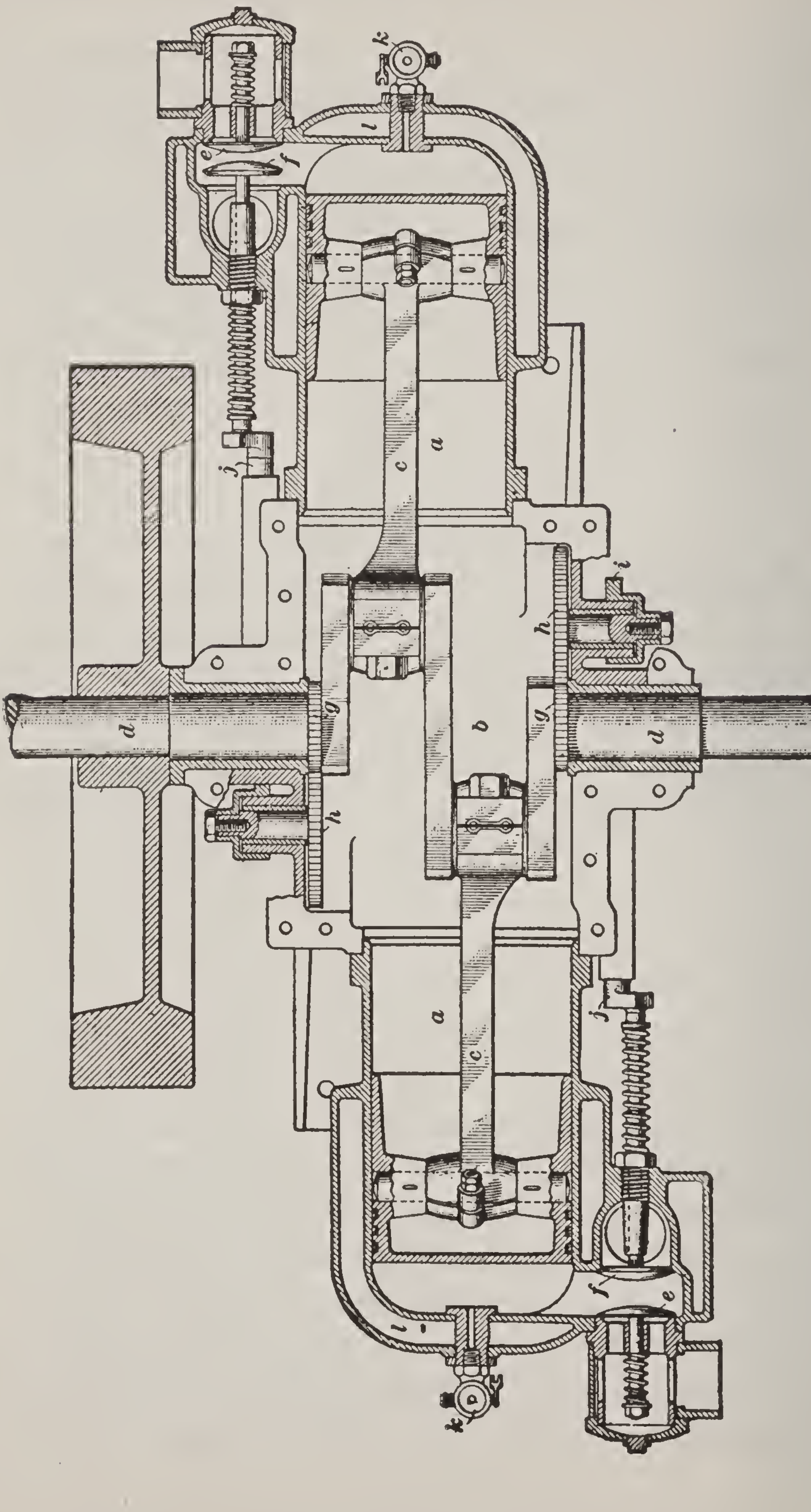


Fig. 153

shaft on which the latter is mounted carrying the exhaust-valve cam i, against which presses the roller of the exhaust-valve push rod j. Compression relief cocks k, mounted in a bushing that passes through the cylinder water-jackets l, are provided for relieving the compression pressure in starting.

Horsepower of Explosive Motors. The first requisite is to find the number of power strokes made per minute by the motor. In a single cylinder motor of the four-cycle type there is one power stroke for every two revolutions, and if the motor has four cylinders there is one power stroke for every revolution of the crank shaft. The number of power strokes then may be found by the following formula (referring to a four-cycle motor):

$$N = \frac{C}{4} \times S$$

in which N = Number of power strokes per minute.

C = Number of cylinders.

S = Angular velocity of crank shaft in revolutions per minute.

Having ascertained the number of power strokes per miute, the horsepower is found by the formula,

$$H.P = \frac{P\ L\ A\ N}{33{,}000}$$

in which H.P = Horsepower.

$P =$ Mean effective pressure (M. E. P.).
$L =$ Length of stroke in feet.
$A =$ Area of piston in sq. in.
$N =$ Number of power strokes per minute.

This formula does not discriminate between mechanical friction and losses in "fluid" friction. A formula that is more arbitrary and that fits the majority of cases, requiring only the use of a few facts, such as diameter of cylinder, length of stroke, and revolutions per minute, is presented as follows:

$$H.P = \frac{V \times N}{10{,}000}$$

in which

$V =$ volume of cylinder in cu. inches.
$N =$ number of power strokes per min.

The constant used varies from 9,000 to 14,000 depending upon certain types of engines; 10,000 being an average figure for four cycle engines. The brake horsepower will be from 65 to 85 per cent of the result obtained; 80 per cent may be taken as an average. As an example we may take a four-cycle, four-cylinder motor 4½-in. bore and 4½-in. stroke making 1,200 power strokes per minute. Volume (V) of cylinder equals area of piston 15.9 sq. in. $\times$ length of stroke 4½=71.55 cu. in., and multiplying this by 1,200 (N) and dividing the product by 10,000 gives 8.05 H.P. Taking 80 per cent of this as the brake horsepower the result is 6.44 H.P.

From a theoretical standpoint a two-cycle explosive motor should not only have as great a speed, but also be capable of developing almost twice the power that a four-cycle motor does. It is a fact nevertheless that its actual performance is far different.

The horsepower of a two-cycle motor may be calculated from the following formula,

$$\text{H.P} = \frac{D^2 \times S \times N}{21{,}000}$$

in which

D=diameter of cylinder in inches.
S=stroke of piston in inches.
N=number of revs. per minute.

Example: Required, the horsepower of a two-cycle motor of 4½ inches bore and stroke, with a speed of 900 revolutions per minute.

Answer: The square of the bore multiplied by the stroke is equal to 91.125, which multiplied by 900, and divided by 21,000, gives 3.91 as the required horsepower. The results given by the above examples agree very closely with those obtained from actual practice.

Hub—Floating Type. Fig. 154 shows a full-floating type of live rear axle in which the bearings are of the annular type, and the driving jaws at the ends of the shafts engage with the hub in a proper manner to abort failure from lost motion.

In this case the tube is reduced in diameter to take the bearings, and the shoulder so formed is taken advantage of in the process of providing for thrust. The shaft has no work to do excepting to take torsional moments, and

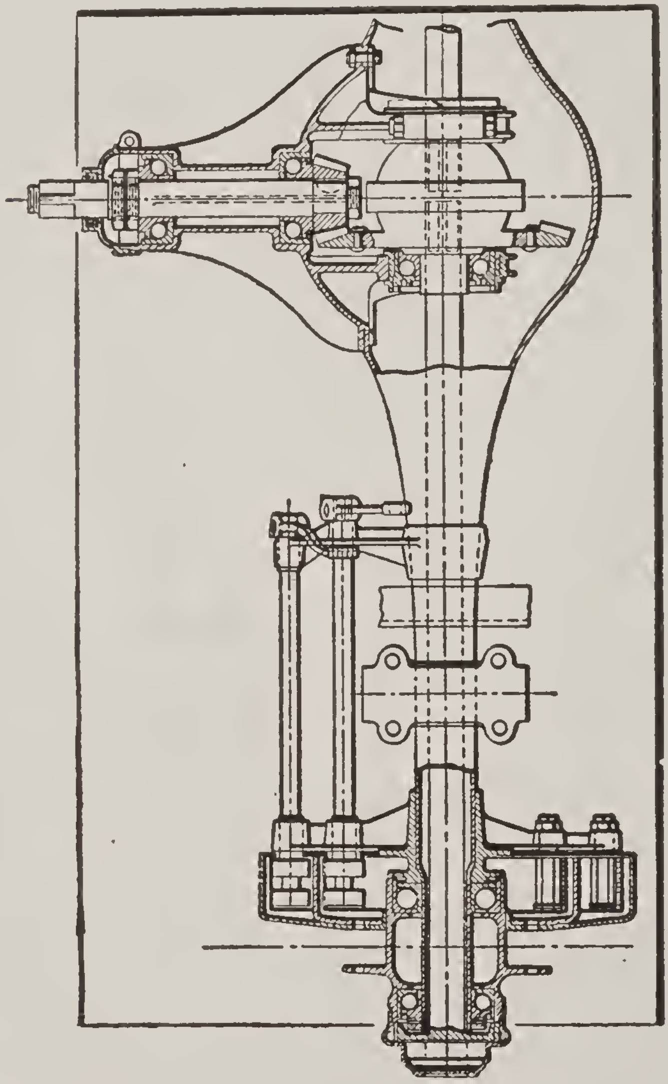


Fig. 154
McCord Full Floating Live Rear Axle With Annular Type Ball Bearings and Parts of Drop Forged Steel

the design throughout includes drop forgings of steel and drawn-steel parts. The inner race of the ball bearings is a sufficiently heavy tube, but it is not shaped in such a way as to act as a "preventer bearing," hence complete dependence is placed on the ball bearings and they are

made large enough to take the responsibility. This class of hub work is much in evidence in various makes of cars, and this particular example is from the 1910 McCord car.

HUB CAP LOOSE. A hub cap, particularly of a plain bearing car whose hubs are greased instead of oiled, will unscrew rather easily if its threads are a loose fit. This is particularly the

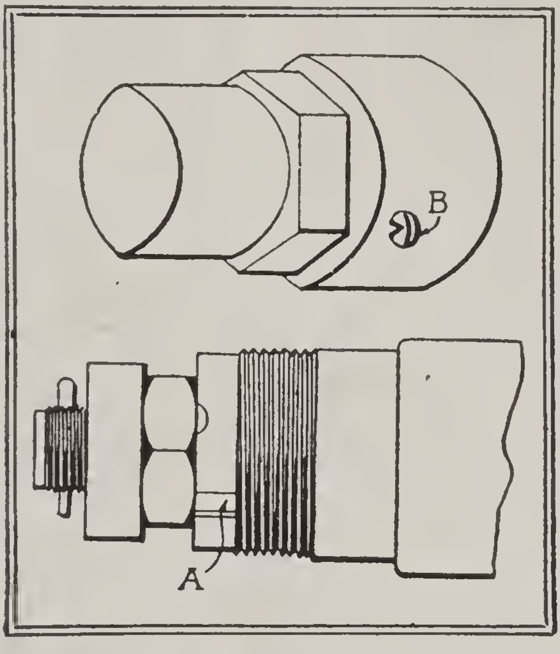


Fig. 155
Illustrates Locking Loose Hub Caps

case with the right-hand hub caps, since the viscosity of the grease results in a constant effort to unscrew them. As good a way as any to lock the cap is to chip the notch, A, Fig. 155, in the flange of the bronze bushing in the hub, and to arrange a set screw in the cap to enter this notch. If the set screw is of the ordinary hardened sort and holds only by its own pressure, it is liable to shake loose some time or other.

A better plan is to use a button head ¼-20 screw of ordinary steel, running the threads clear up to the head by means of a die. A notch is filed in the head of the screw, as shown at B, and the screw is cut off to such a length that the head will bottom on the cap when the end of the screw enters the notch A, then a burr is raised at B in the brass of the cap with a prick punch; thus the screw is secured against turning until it is wanted to do so. The same expedient is useful in many other places where it is desired to keep a screw from loosening.

Modern Hub Practice. The trend is in the direction of ball and roller bearings for wheels, the hubs being accurately machined from steel castings, or die forgings. Hub flanges are wide, and a suitable number of bolts of good diameter are used to bolt the woodwork into secure relation.

There is a decided tendency, also, to have the spokes at the mitre very accurately fitted, and fastened by glue, so that the wheel may be easily disassembled at any time, for any purpose, as for instance, a new hub might be substituted at will for one that has been damaged in service.

Hydraulic Clutch. Fig. 156 illustrates the principle upon which the hydraulic clutch works. The spider A is secured to the engine shaft and carries two spur pinions B, B, which are in constant mesh with the spur gear C, attached to the driven shaft.

Spaces H, H, H, H are sections of a liquid tight casing, which is filled with oil.

The gears and oil spaces constitute a rotary pump tending to circulate the surrounding oil. Several valves, one of which is shown at **D**,

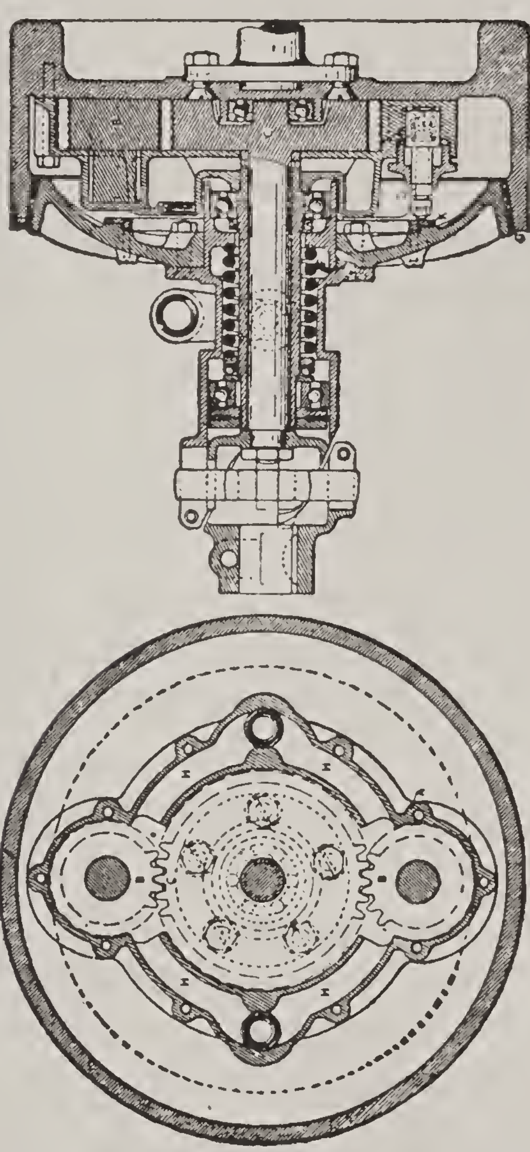


Fig. 156
Hydraulic Clutch

when opened, allow the free circulation of the oil through passages not shown, but when D is closed the oil is impounded, and practically no relative motion is possible between the pump members. When the valves are opened, and

the oil is allowed to circulate freely, pinions B, B, on the engine simply run idly around the central gear C, and no torque is transmitted to the driven shaft, but when the oil valves are partially closed, the resistance between the pump members is increased and a driving effort is communicated to gear C and the driven shaft. When the valves are fully closed, no relative motion is permitted between the pump members, the result being that pinions B drive gear C and the driven shaft with only a slight amount of slip due to oil leakage. The clutch is operated by releasing a pedal, allowing spring F to act and bring the ring K into contact with the ball bearing heads of the oil valves D, which have previously been held fully open by their springs. As the valves are more or less closed by the release of the pedal, the clutch torque increases, due to the action of the gear-pump, consequent upon the impounding of the oil, until finally they are entirely closed, when the driven shaft will then revolve at about 90 per cent of the engine speed. A still further motion of the clutch causes engagement of the leather-faced conical surface G, thus locking the clutch to the engine shaft mechanically.

The object of this device is to automatically insure an easy starting of the car, independent of the operator, and it is claimed that it serves much the same purpose as a change of gears in the starting operation, and that there is no serious heating of the oil under such conditions.

Hydrogen Generator—Principle of. Hydrogen when combined with oxygen makes a flame sufficiently hot to melt lead locally, and the burning process as it is applied to battery work becomes a reality. Oxygen is available in the air in sufficient quantity to allow of the use of

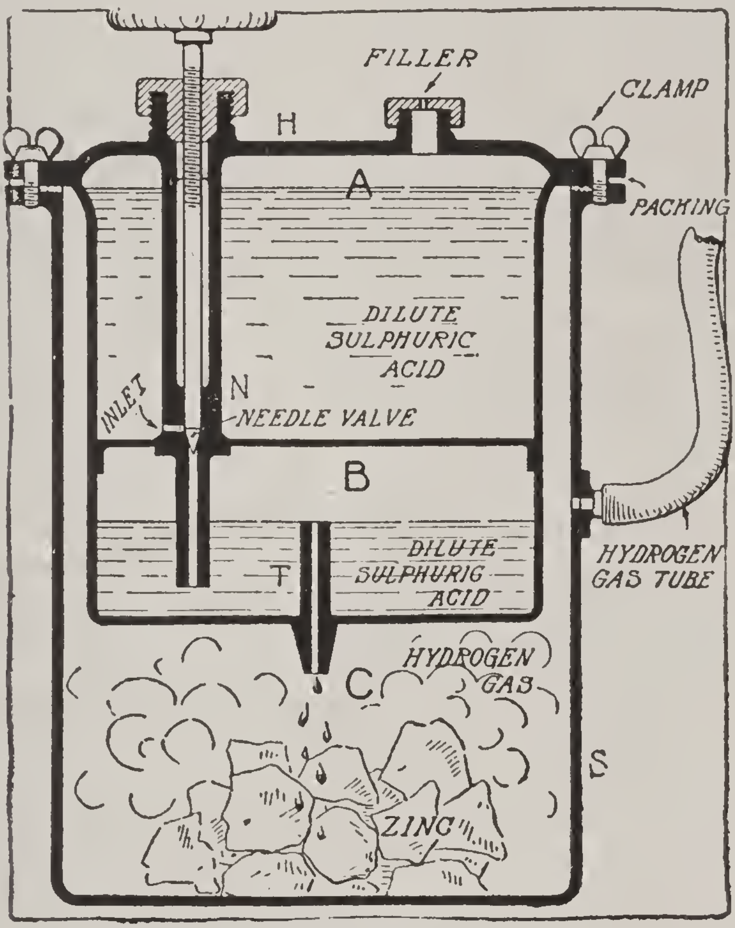


Fig. 157

the hydrogen flame, provided the latter element is available under slight pressure. To obtain hydrogen under slight pressure in sufficient quantity a hydrogen generator is used and is so contrived that the pressure is automatically limited to that due to a few inches of water. Fig. 157 illustrates the principle of construction at-

tending such a generator, cut through the middle, showing an outside shell S, the bottom of which is filled with zinc. From the top a two-compartment container H is inserted, with means for rendering the same tight around the seam at the top. The upper compartment A is filled with dilute sulphuric acid, and by means of the needle valve N the sulphuric acid is allowed to drip into the lower compartment B until it rises to the top of the connecting tube, above the line of the drip tube T from the upper compartment and passes below. When the sulphuric acid passes down through the tube T and contacts with the zinc in the bottom chemical action is set up with a reaction as follows:

$$H_2\,S\,O_4 + Zn = Zn\,S\,O_4 + H_2$$

The middle chamber C acts as a seal and when the pressure of hydrogen equals the pressure of the column of dilute sulphuric acid the action terminates because no more sulphuric acid will flow until the hydrogen-gas pressure is decreased, as it will be if the hydrogen is consumed. In practice the process is continuous and automatic, thus enabling the operator to burn the lead joints as rapidly as they can be made up.

Fig. 158 illustrates a form of generator that accords with practice, the principle being the same as that shown in Fig. 157, with the differences in detail as follows: The receptacle A for sulphuric acid may be of any convenient shape,

but it must be tight. The pipe P leads to the tank B, which is provided with a large hand hole K to use in passing the zinc to the inside and in cleaning out as occasion requires. Sulphuric acid poured into B contacts with the zinc and hydrogen gas is formed. The pressure

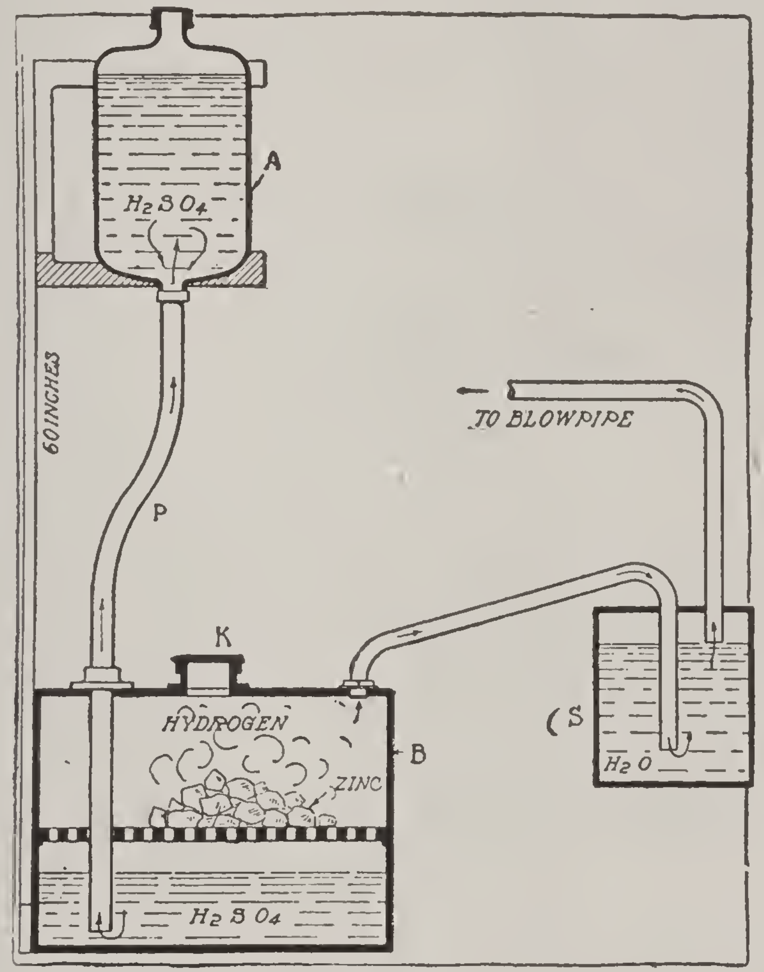


Fig. 158

will be equal to the effective head of the column of sulphuric acid, the excess acid is forced up into the receptacle A, and the formation of gas is interrupted, due to the uncovering of the zinc when the liquid passes up into A. The hydrogen gas passes on to the burner through the

filter-safety S. This water trap, acting as a safety, not only scrubs the gas but it prevents air from passing into the generator and in this way safety is assured.

Fig. 159 shows details of the process after the joints are made up, following the work of scraping the necks of the plates, and the sur-

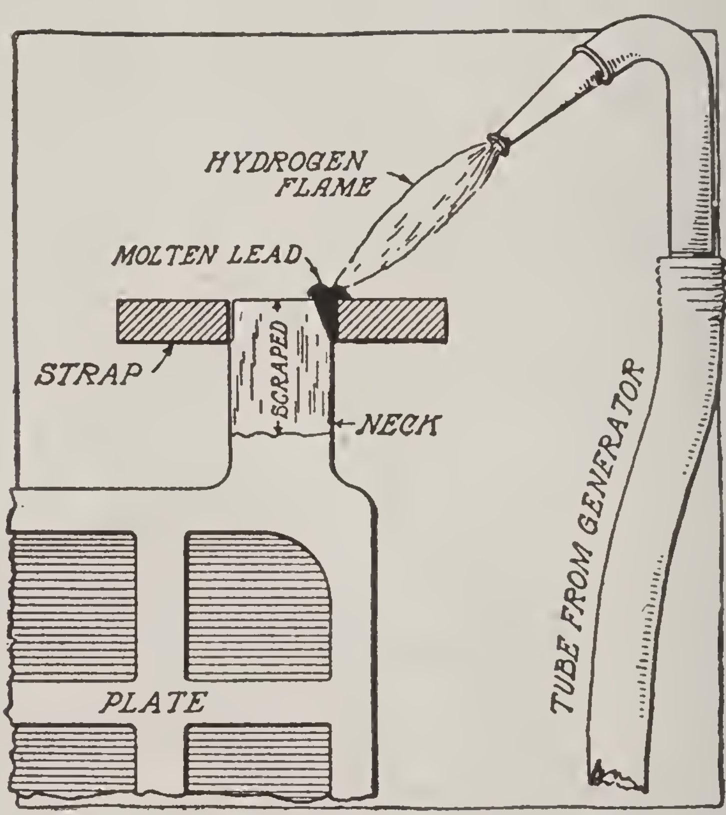


Fig. 159

faces of the strap, in order to obtain a clean, bright metal-to-metal contact.

Under no circumstances will lead run together unless the surfaces are clean and bright; they must not stand for any length of time after scraping, because a coating of sulphate of lead will form over the scraped surfaces and the process of burning will be defeated.

Ignition. In order that an explosive motor may operate economically, and with the highest percentage of efficiency, it is absolutely necessary that two objects shall be attained, viz.: A correct mixture of the gasoline and air, and that this mixture be correctly ignited at the proper time.

Ignition of the explosive mixture is accomplished by two methods, the electric spark and the incandescent tube; the latter system, however, is falling rapidly into disuse.

ELECTRIC IGNITION. This form of ignition is in general use, two methods being employed, as follows:

(a) Primary electric ignition, and (b) secondary electric ignition.

In the common parlance, these are called low tension and high tension, the former being given the additional name of the make-and-break system, while the latter is more often called the jump-spark system. The latter is, moreover, subdivided again according to the source of current, although for sparking purposes, all sources are alike. These are:

(a-1) Dry cells.

(a-2) Storage batteries.

(a-3) Magnetos or generators.

(a-4) Small dynamos and other sources of current.

There are two methods of producing an electric spark for ignition purposes: The first, by means of an induction coil which has only a

single winding, composed of a few layers of insulated copper wire of large size, wound upon a bundle of soft iron wires, known as the core. The second, by the use of an induction coil with a double winding upon its core. The inner winding being composed of a few layers of insulated wire of large size, as in the coil just described, and an outer winding consisting of a great many layers of very small insulated copper wire, in fact, several thousand feet in length.

The coil first described is known as a primary spark coil, from the fact that the spark or arc is produced by the direct effect of the battery or generator current flowing in the coil. This form of spark will not arc or jump across a space between two points, but simply occurs between the contact points on the breaking of the contact.

The second form of induction coil is commonly known as a secondary spark coil, because the arc or spark is produced in the secondary winding of the coil, and will jump or arc across a space between two fixed points, without the points first coming in contact.

Induction Coil. Induction is the process by which a body having electrical or magnetic properties calls forth similar properties in a neighboring body without direct contact. This property is known as self-induction, and is caused by the reaction of different parts of the same circuit upon one another, due to varia-

tions in distance or current strength. The current produced by an induction coil has a very high electro-motive force, and hence great power of overcoming resistance.

The average user of an automobile is well aware that without the battery and the spark coil the motor would not operate. He has learned that, when the spark fails, there are certain forms to be gone through to ascertain the cause of trouble, but as there are other diffi-

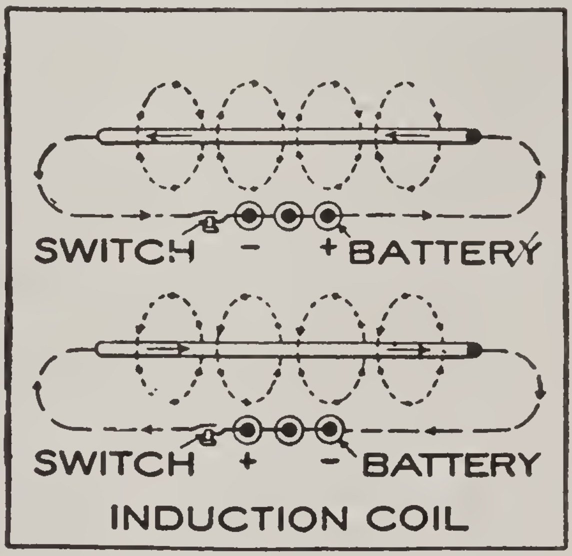


Fig. 160

culties, it is desirable that more should be known of this important subject.

If a current of electricty be caused to flow through a straight conductor forming a part of a closed electric circuit, lines of force, commonly called magnetic whirls or waves, are induced in the air and rotate around the conductor.

If the current of electricity be flowing in the circuit and through the straight conductor from

right to left, as shown in the upper view in Fig. 160, the lines of force or magnetic whirls will rotate around the conductor from left to right, or in the direction of the hands of a clock. On the other hand, if the conditions be reversed and the current flows from left to right the lines of force or magnetic whirls will rotate from right to left, as shown in the lower view in Fig. 160. The direction of rotation of these lines of force or magnetic whirls may be positively determined by the use of a galvanometer, an electric testing instrument having a needle similar in appearance to that of an ordinary compass. Upon placing this instrument in the path of the lines of force and making and breaking the battery circuit by means of the switch, the needle of the galvanometer will be deflected from its zero point in the direction of the rotation of the lines of force. If the direction of the flow of the electric current through the circuit be changed by reversing the poles of the battery, the needle of the galvanometer will be deflected from its zero point in the opposite direction. Whether these lines of force or magnetic whirls rotate continuously around the wire has not been demonstrated. They rotate with sufficient force to be tested by the galvanometer only until the electric current in the closed circuit has reached its maximum value after closing the circuit; that is to say, only during the infinitesimal space of time required by the current to reach its full value or power.

If, instead of a straight conductor, a loop of insulated wire, in the form of a circle, be untilized for the passage of the current, as at A and B in Fig. 161, the lines of force will still rotate around the wire as shown, their direction being dependent on the direction of the electric current. If the electrical circuit be provided with

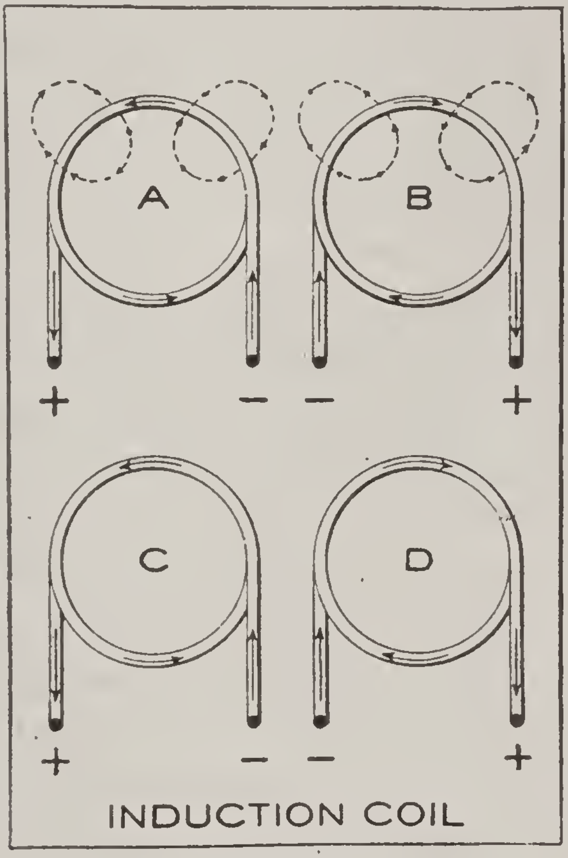


Fig. 161

a current reverser, or device for changing the battery connections in the circuit from positive to negative and vice versa, the lines of force can be made to rotate rapidly first in one direction and then in the other, as indicated in Fig. 160.

Suppose this loop of insulated wire be composed of a great number of turns, it then be-

comes a coil or closed helix, and as all the lines of force cannot pass between the turns of the electrical conductor forming this helix they must pass completely through the helix instead of rotating around a single loop, as at A and B, Fig. 161. If the current flows through the conductor in the direction indicated by the arrows, at C in Fig. 161, and over and around the coil in the direction shown, the lines of force will flow through the coil towards the observer, and complete their path or circuit through the air, returning into the coil at the opposite end. If the current be reversed and flow around the coil in the direction of the hands of a clock, the lines of force will flow through the coil in the opposite direction, that is, away from the observer, as at D, Fig. 161.

This form of coil or closed helix may be designated as the primitive form of an electromagnet. When forming part of a closed electric circuit it possesses the property of magnetizing a bar of wrought iron placed within it. If a short round bar of wrought iron be placed a short distance within the coil, and the battery circuit be closed, the iron bar will, if the current is sufficiently strong, be sucked or drawn into the center of the coil, and a considerable effort will be required to withdraw it.

The object of the bundle of soft iron wires, which form the core of any form of spark coil, is to increase the magnetic effect of the lines of

force or magentic flux, or rather to reduce the resistance to their passage through the coil.

As the resistance of air to the flow of the lines of force is about 100,000 times greater than that of wrought iron, the introduction of the iron core into the coil increases its magnetic effect enormously.

As has been previously stated, when a current of electricity flows through a conductor of wire forming a coil or closed helix, lines of force are

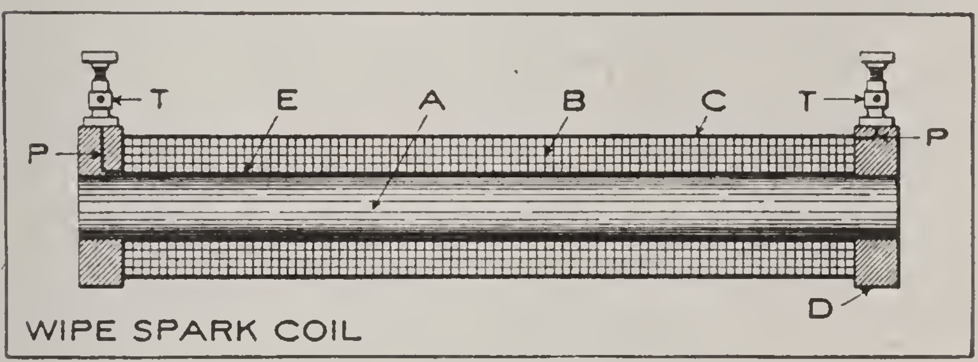


Fig. 162

induced and flow through, and also around the exterior of the coil. In a like manner, when the electric circuit is broken, the lines of force suddenly reverse their direction, and travel through the coil with a tremendous velocity until they reach a state of neutralization. During this reverse travel of the lines of force through the coil, a current of electricity is induced in the winding of the coil, but in the opposite direction to that in which the battery current was flowing. The effect of this induced current, which is of far greater intensity or pressure than the bat

tery current which induced it, is to form an arc or spark at the breaking point in the circuit.

Primary Spark Coil. Fig. 162 shows a vertical longitudinal section through an induction coil of the form first described, and known as a wipe or touch spark coil. It consists of two principal parts, a core, made of a bundle of soft iron wire, and a coil of wire around this core composed of from 3 to 5 layers of turns of insulated copper wire, varying in diameter from No. 16 to No. 12, B. & S. Gauge, according to the battery conditions under which the coil has to operate. The iron core may vary from three-eighths of an inch in diameter and 6 inches long, to three-fourths of an inch in diameter and 12 to 15 inches long, depending upon the intensity and capacity of the spark required. Reference to the drawing will show that the core A has upon its ends wood or fiber washers D. They may be square or round. Upon the portion of the core between the washers is a paper tube E, upon which the wire forming the primary winding is wound. The ends of the wire forming the coil and shown at P are connected to the binding posts or terminals indicated by the letter T, and located on top of the washers D. The wire B, forming the primary winding, is usually provided with an outer casing, as shown at C, to protect it from water and grease.

The form of induction coil above described is generally used for ignition purposes on gas and gasoline motors fitted with a mechanical make

and break form of spark, which is located within the combustion chamber of the motor itself.

Secondary Spark Coil. Fig. 163 shows the secondary or jump-spark form of coil. It is composed of an iron core and a primary winding similar to that described in conjunction with Fig. 162, with the addition of an outer winding of many turns of fine wire. This wire, of very small size, is known as the secondary winding, varying in diameter from No. 36 to No. 40 B. & S. Gauge, and in length from 5,000 to 10,000 feet. In the drawing the induction coil is shown equipped with an electro-magnet make and break, or vibrator device, which is the form mostly used for ignition purposes. The other form, known as the plain jump-spark coil, has a mechanically operated make and break device attached to the motor to operate the coil.

The arc or spark produced at the breaking point of the electrical circuit in which the primary winding of the coil is connected is not utilized for ignition purposes in this type of coil. When the circuit is broken the sudden reaction or backward flow of the lines of force or magnetic flux in the iron core produce an induced current in the secondary winding, but in the opposite direction to that of the battery current. This induced current is of so much greater intensity and velocity than that induced in the primary winding by this same reaction, that the arc or spark induced in the secondary winding of the coil will jump across a space

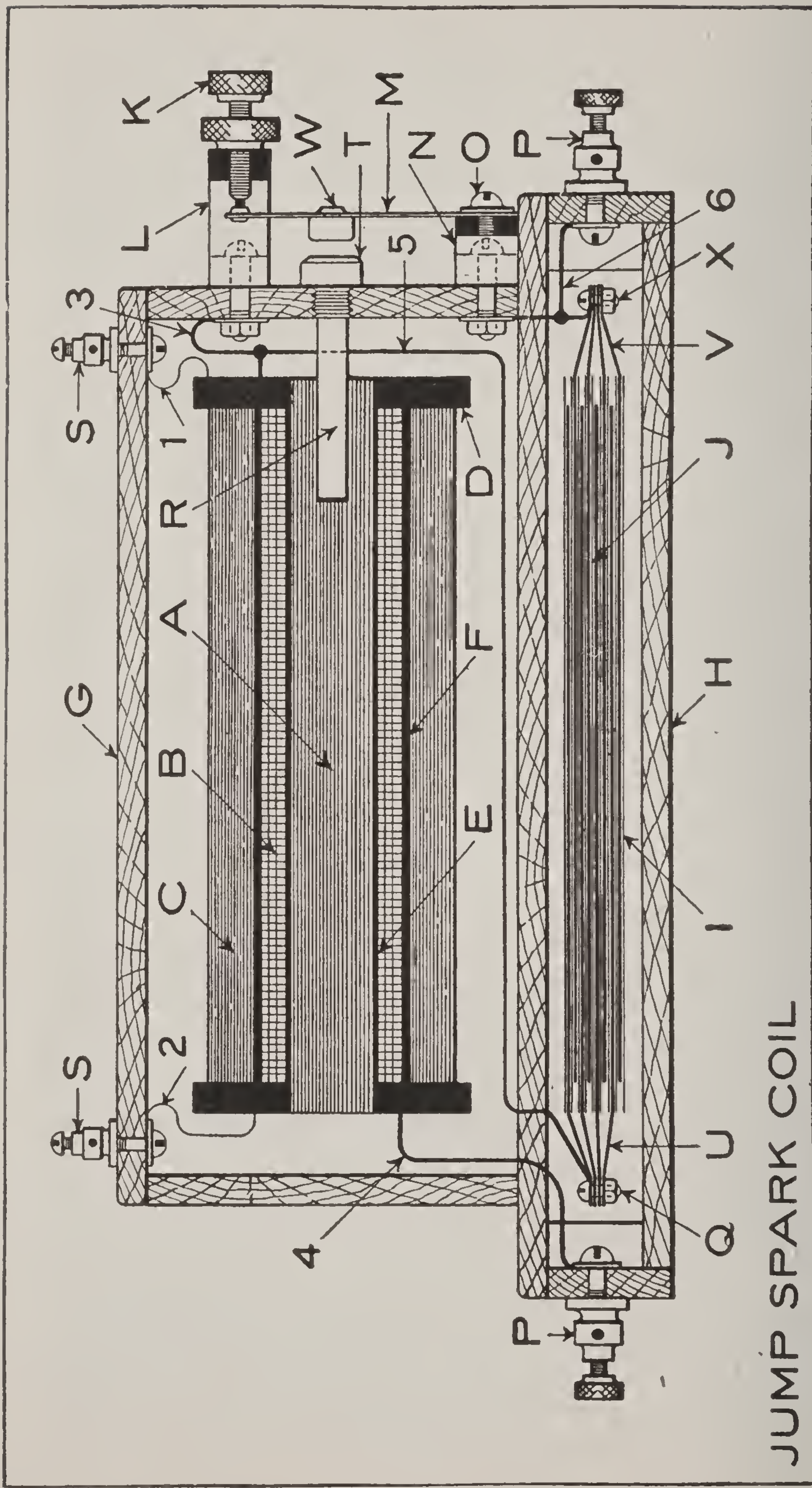


Fig. 163

from one end of the wire to the other, varying from ⅛ inch to as much as 8 or 10 inches in length, dependent upon the length of wire in the secondary circuit, the electro-motive force of the battery and the frequency of the interruptions or number of times per minute the electric circuit is made and broken.

Referring to Fig. 163 A is the core, B the primary winding and C the secondary. The two coils are held in place upon the core by the washers D. The primary wire B is wound over a paper tube E, and the secondary wire C is insulated from the primary wire by a mica insulating tube F. The coil proper is enclosed in a wood case G.

The terminals or binding posts on top of the case G are connected with the ends of the secondary wire 1 and 2. The secondary terminals are plainly indicated by the letter S. In the base H of the coil case is the condenser J, an essential feature of this form of coil, which utilizes the induced primary current to produce a greater reactive energy in the secondary winding.

At the right-hand end of the coil and outside the casing G is located the electro-magnetic vibrator or trembling device, which automatically makes and breaks the primary circuit. The end 3 of the primary wire is connected with the contact screw K through the bracket L. The spring M, carried by the bracket N, with screw O, is connected with the terminal or binding

post P, immediately beneath it, by the wire 6 through the bracket N. The end 4 of the primary wire is connected with another terminal or binding post P, at the other end of the base of the coil. The condenser J is connected across the contact points of the screw K and the spring M, by the wires 5 and 6 and screws Q and X. The condenser is composed of a number of sheets of tinfoil V, laid between sheets of specially insulated paper I, with the opposite end of every alternate sheet of tinfoil projecting from the paper insulation, as shown. These projecting ends are connected together, and by the wires 5 and 6 to the contact screw K and spring M, respectively, as previously described.

When the coil is connected in, or forms part of a closed electric circuit by means of the terminal or binding posts P, on the base of the coil, the current flows through the primary winding B. This instantly produces a high degree of magnetism in the core A, and the pole-piece T of the core extension R becomes strongly magnetic and attracts the iron button W of the spring M. This draws the spring M away from the end of the screw K, and in consequence breaks the electric circuit. This results in the demagnetizing of the pole-piece T and the consequent return of the spring M to its normal position in contact with the end of the screw K. So long as the electric circuit remains closed this operation is repeated at a very high rate of speed. The effect of this continuous opera-

tion of the coil is to produce an intermittent current in the secondary winding of high intensity and velocity. If wires are placed in the holes in the small terminals or binding posts on the top of the coil and brought within a short distance of each other, a stream of sparks will pass from one wire to the other in a peculiar zigzag manner and emit a loud, crackling noise, accompanied by a peculiar odor, caused by the formation of ozone through the electro-chemical action of the spark.

Under ordinary circumstances the arc or spark which occurs on the breaking of the contact between the platinum points of the screw K and spring M would not be utilized, but by means of the condenser in the base, which is connected to these parts, as before described, the static charge of electricity generated by this action is stored in the condenser. When the contact is again made this stored electric energy is given up or discharged by the condenser and flows through the primary winding of the coil in connection and in the same direction as the battery current and increases the magnetic effect of the core A enormously.

When the coil is used in connection with a gas or gasoline motor a form of ignition device known as a spark plug is used. This is connected with the secondary terminals and screwed into the combustion chamber of the motor. A form of circuit breaker upon the motor is used to make and break the electric

circuit at the desired point, and the resulting arc or spark inside the combustion chamber ignites the charge of vapor.

This style of coil is sometimes used without the electro-magnetic vibrator, and a mechanical make and break device, actuated by the motor, is used instead, producing as a rule only a single spark.

To remove any doubt as to the origin of the secondary or jump-spark form of induction coil, it may be here briefly stated, that it was invented by Rumkorff in the year 1851, long before the inception of the automobile.

Source of Current. As previously stated, there are several sources from which the electric current may be taken for ignition purposes, among which are dry cells, storage batteries, magnetos or generators, and small dynamos. Storage batteries will be treated upon later on. A few words regarding dry batteries, and magneto generators may not be out of place at this juncture.

Dry Batteries are very generally used on moderate speed and low-priced cars. They are simple in construction, comparatively simple in operation, and their action is easy to understand. Each cell is composed of three elements: The carbon, the zinc, and the electrolyte. The carbon usually takes the form of a round stick placed in the center of a cylindrical vessel made of zinc in sheet form. The space between the carbon and the zinc is filled with the electrolyte,

generally a solution of sal-ammoniac, which is poured in on crushed coke. The top is closed, or rather sealed, with pitch to prevent the loss or evaporation of the liquid. Through this, project the ends of the carbon and the zinc, these being formed into binding posts for holding the wires. As this holding of the wires must be an intimate relation, the usual form is a threaded shank upon which a pair of nuts are mounted. Between these the wire to be connected is crushed or compressed by the moving together of the nuts.

The two poles or binding posts are called the positive and the negative, and are indicated by the + sign for the former and the — sign for the latter. Carbon being the positive element, the + sign attaches to it. Now, the act of connecting these terminals together so as to allow a flow of current allows of two different methods of procedure, a right and a wrong way, it is true, but that was not what was meant.

In one respect dry batteries have a decided advantage over storage batteries for ignition purposes, from the fact that on account of their high internal resistance they cannot be so quickly deteriorated by short circuiting.

On account of this high internal resistance, dry batteries will not give so large a volume of current as storage batteries, but a set of dry batteries may be short circuited for five minutes without apparent injury and will recuperate in from twenty to thirty minutes, while a

storage battery would in all probability be ruined under the same conditions.

If dry batteries only are used for ignition purposes, two sets should be carried, of not less than 6 cells each, connected with a two-point switch. One set of batteries should be used not to exceed thirty minutes and then the other set switched on. In this manner the batteries will have a much longer life than if used continuously.

To ascertain the internal resistance of a dry or primary battery, proceed as follows: With a suitable voltmeter, obtain the voltage of the battery at its terminals when on open circuit. With a known resistance in the battery circuit —say 100 feet of No. 10 B. & S. Gauge copper wire—again obtain the voltage of the battery, also note the amperage with an ammeter; this, however, must be done quickly before polarization occurs.

Let V be the voltage of the battery at its terminals when on open circuit, and v the voltage of the battery with a known resistance in the circuit, let C be the current in amperes flowing through the known resistance and R the required internal resistance of the dry or primary battery, then

$$R = \frac{V - v}{C}$$

To demonstrate the truth of the above for-

mula and also to prove the correctness of the instruments used in making the test, when the value of the internal resistance R has been ascertained, then C, the current flowing with a known resistance in the battery circuit, should equal in value the result of the formula given below, which is

$$C = \frac{V - v}{R}$$

Dry batteries which have become exhausted may in most cases be recuperated in the following manner: First disconnect the cells from each other and remove their pasteboard covers, then drill a hole in the sealing compound on top of the cell, about one-quarter of an inch in diameter and at least 2 inches in depth so as to insure getting below the sealing compound. Take 1 ounce of bisulphate of mercury and put in a porcelain or earthenware vessel (on no account use a metal vessel) and pour over it one-half pint of boiling water—when cold, draw off the clear solution, being careful not to disturb the yellow precipitate left at the bottom of the vessel, which is useless and should be thrown away at once, as it is a rank poison. Dissolve 4 ounces of sal-ammoniac in 1 pint of hot water, and when cold mix with the first solution and the recuperative agent is then ready for use. Take a small glass funnel, or a tin one that is thoroughly painted or enameled, and intro-

duce about a tablespoonful of the liquid into each cell through the hole already drilled for this purpose. The liquid must be introduced into the cells very slowly, as it will take a long time to absorb, and the cells should be allowed to stand at least 12 hours after filling before being ready for use.

THE MAGNETO—ADVANTAGES OF. Without a proper supply of ignition current it is impossible for a motor, running with the best possible mixture of gasoline and air, to give its maximum power. Both the dry battery and the storage battery labor under the same disadvantage, viz.: that they are sources of current that are entirely external to the motor, and must be periodically replenished, similar to gasoline and lubricating oil. Moreover, the changes which these batteries undergo are chemical and of course invisible, and if the batteries are not tested at stated periods, certain defects are not apparent until current is called for. A magneto on the other hand is a purely mechanical apparatus, operated by the engine, thus relieving the autoist of all anxieties resulting from dependence upon an outside source of current. An extended description of various types of magnetos, together with an explanation of the principles controlling their action, is given under the head of Magnetos.

IGNITERS—SYNCHRONIZING OF. The synchronizing of igniters is most easily and accurately done with the aid of one or two cells of battery

and a volt-meter. If the battery is part of the standard reserve equipment it is not necessary to make any change in the connections, except to break the connection from the switch to the bus bar and insert the voltmeter. Then the spark lever is fully retarded, and the flywheel turned to one of the dead positions, which are usually marked on it. This position should be the breaking position for whichever igniter is in action at that instant.

While contact is established the voltmeter will indicate the fact, and the instant contact is broken the needle will return to zero. Adjust the igniter rod up or down until on two or three successive trials the break occurs at exactly the right point, and see that tightening the locknut on the igniter rod does not change this adjustment. Turn the crank again and watch carefully the movement of the igniter rod after the contact is made. If it does not move up half its total travel after contact is made, take off the igniter plate, slacken the taper fit of the outer arm on the rocking stem, and turn the arm very slightly downward. Replace the igniter plate and readjust the igniter rod. When the first cylinder has been satisfactorily timed, take the second, and so on. It is best to cut out all the cylinders except the one under test.

In a make-and-break igniter the grounded electrode is the rocking stem and finger. This stem is lubricated by what oil may chance to

pass it from the combustion chamber. Usually this oil is sufficient for lubrication, and it may be so abundant as to interfere with the flow of current. It is not uncommon to see sparks jumping from this electrode to adjacent parts when the motor is running fast. In case misfiring is noted, and the insulation of the lava bushings is known to be good, a light coil spring may be connected between the rocking stem and any

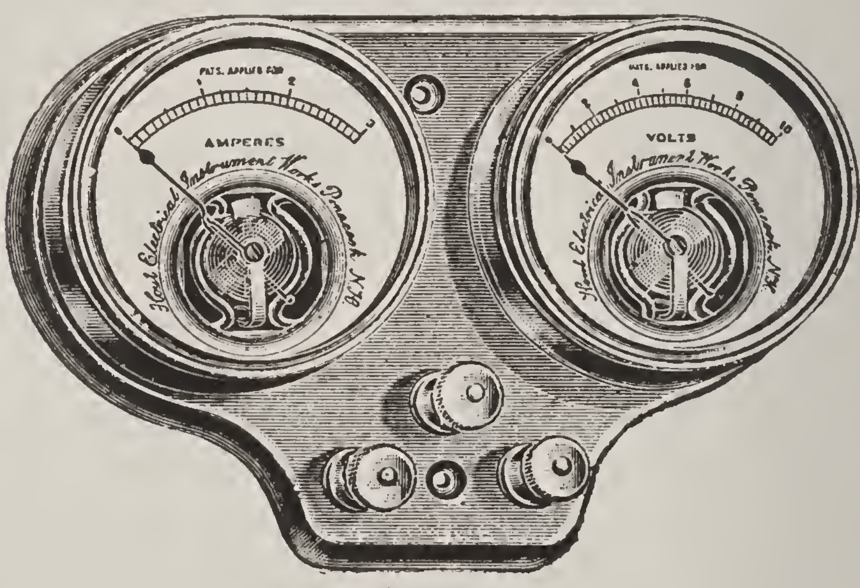


Fig. 164
Hoyt Voltammeter Which Simplifies Ignition Testing

adjacent grounded part, such as one of the studs holding the igniter plate. This spring should not be stiff enough to interfere with the make-and-break movement. Soft copper wire is the best material for it, and one end of the wire may be soldered to a copper "battery terminal" held by the stud nut, this making a permanent and reliable method of fastening electrical connections.

Ignition Testing. The life of an ignition battery depends upon the current consumption of the spark coil, and if adjustments are made in conformity with the indications of current measuring instruments the battery will last much longer, and all parts of the ignition system will give better service. Too small a gap

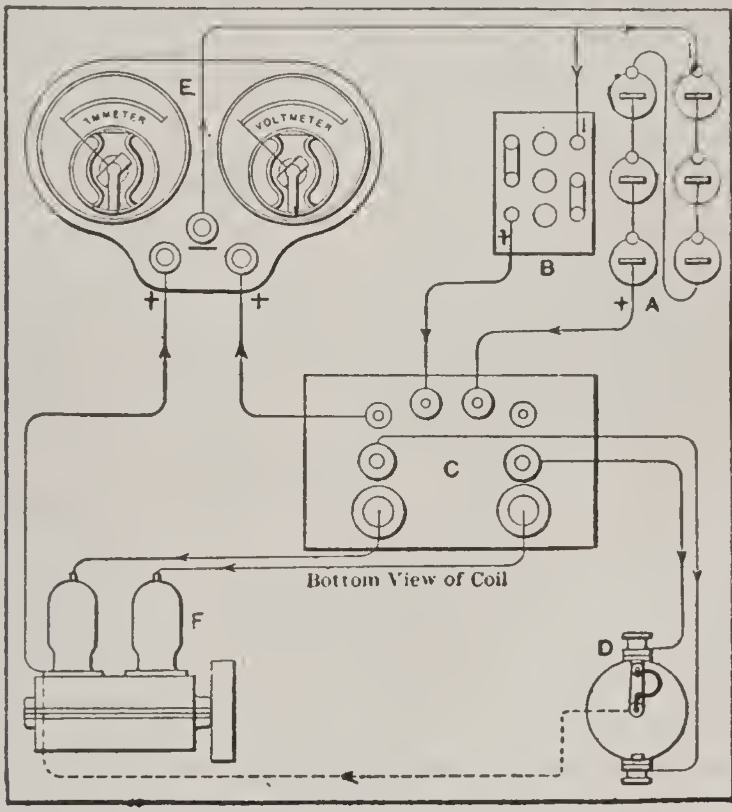


Fig. 165
Wiring Diagram, Showing Coil Binding Posts

at the vibrator increases current consumption, causing a rapid depletion of the battery, as well as pitting and sticking of the vibrator points. Too wide a gap lessens the current flow thus causing misfiring.

The same proposition applies with equal force at the spark plug points. Figs. 164, 165 and 166

illustrate a device known as a voltammeter which can be made a fixed part of the battery circuit, thus furnishing a continuous and visible record of battery performance under working conditions, and by means of which faults may be readily detected and remedied. The apparatus consists of two instruments, an ammeter and a voltmeter, mounted on a common base that is

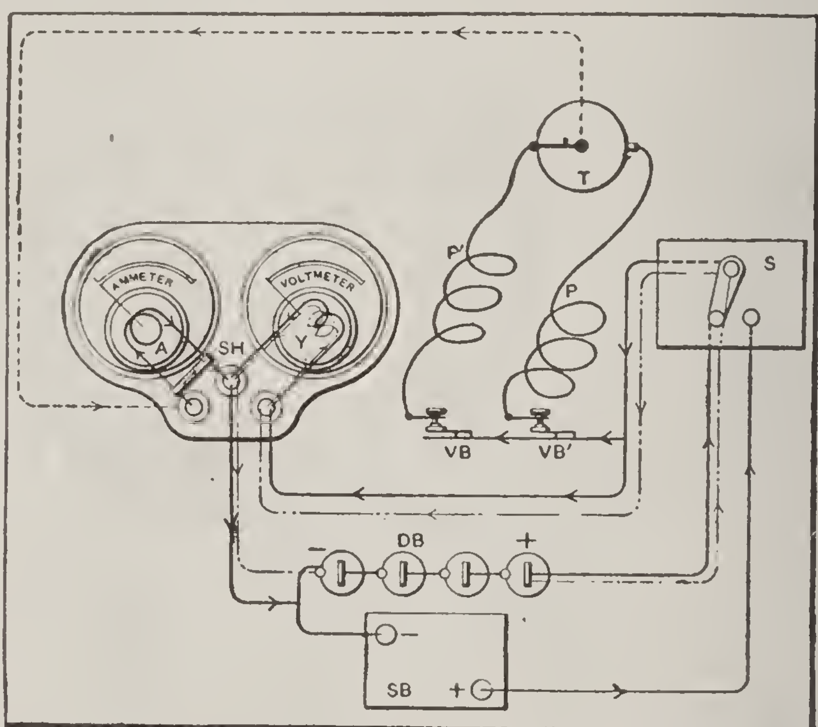


Fig. 166
Voltmeter Indicates Condition of Circuit

attached by screws directly to the dash if of wood, or to an insulating block in case the dash is of metal. The voltage of the primary, or battery, circuit is measured by the instrument at the right, while the strength of the current in amperes is measured by the one at the left. Both instruments operate on what is commonly known as the D'Arsonval principle, a perma-

nent magnet being employed to create a strong magnetic field of practically unvarying intensity, within which a rectangular coil of fine wire, wound on a centrally pivoted aluminum open-frame bobbin, mounted between the pole pieces of the magnet, is made to rotate against the opposing influence of a spring, by the current that passes through it. Attached to the coil bobbin, or frame is a pointer that moves over a scale so graduated as to indicate the strength, (amperage) or the pressure, (voltage) of the current, causing a deflection of the swinging needle from its normal or zero position. Fig. 165 shows the method of connecting the voltammeter, and it will be seen that the carbon, or positive (+) terminal of the dry cell battery A, and also positive (+) terminal of the storage battery B are connected to the terminals of the coil C from which wires are led to the timer D by which the primary or dry cell circuit is closed. From the contact screw of either of the coil units a wire is led to the right hand binding post of the voltammeter, and the zinc or negative (—) terminals of both batteries are connected to the central(—) binding post of the instrument. The return circuit wire is connected to the left hand binding post of the voltammeter. The current loss due to the operation of the instrument is reduced to a negligible quantity, notwithstanding that the voltmeter is connected across the main leads as shown in Fig. 166. The ammeter is connected

in series in the primary circuit, but the current is caused to pass through a shunt conductor S. H., Fig. 166, having somewhat higher resistance than the other parts of the circuit, but still of sufficiently low resistance to make the current loss due to its use a negligible factor also. The coil of the ammeter is connected in parallel with the shunt, forming a divided circuit, a very small portion of the current passing through the coil, while the rest passes through the shunt. Referring to Fig. 165, current from the primary battery A, or from the secondary battery B, whichever happens to be in use, passes through the primary winding of the coil C when the circuit is closed by the timer D.

From coil C current flows into the voltmeter through the wire attached to the right hand binding post, and thence back to the battery. When the timer closes the circuit through the coil, a portion of the current that flows through the timer ground circuit passes into the ammeter and out to the center binding post, thence back to the battery. The largest portion of the current passes directly from the left hand binding post to the center binding post through shunt S, H, Fig. 166. The return circuit between timer D and engine F, Fig. 165, is indicated by the dotted line, the direction of flow being shown by the arrows. In Fig. 166 the voltmeter circuit when switch S is closed is indicated by the dot and dash line. Current from dry battery D, B, flows through primary

P^1, timer T, ground and left binding post of voltammeter, passes through shunt S, H, and ammeter coil A.

To make a test with the device, first make the distance between spark plug points as nearly uniform as possible, the gap not to exceed .03 in., and then file the platinum points of the vibrators and contact screws so that they are flat and true as well as smooth. After filing the points, the contact screws of each unit should be adjusted so as to give the vibrator 1-16 in. play between screw and iron core. Then with the gasoline supply to the carbureter shut off, and compression relief cocks open, turn the engine over until the timer makes contact and sparking occurs in one of the cylinders. Note the reading of the ammeter when the timer closes the primary circuit, and if the current consumption of the coil exceeds .8 ampere, increase the vibrator gap by unscrewing the contact screw, thus decreasing the flow of current. Should the vibrator fail to act, however, screw down the contact screw thus decreasing the gap until the vibrator acts. Proceed in this manner to adjust each of the vibrators until the current consumption is the same on all.

In making adjustments while the engine is at rest it is necessary to adjust for a current consumption about twice as great as is desired in actual operation owing to the fact that when the engine is at rest the circuit is closed for a

considerably longer time than when running and the flow of current is intermittent.

Thus if a two unit coil be adjusted to take $\frac{3}{4}$ ampere while at rest, it would consume only $\frac{3}{8}$ to $\frac{1}{2}$ ampere while engine is in operation. With the car in operation, a glance at the ammeter will show whether there is a normal flow of current through the coil. The instrument will also serve as a reliable guide in the location of ignition troubles and their remedies as may be seen by the following table:

TABLE OF COMMON IGNITION TROUBLES AND REMEDIES.

Reading of Voltmeter	Corresponding Ammeter Reading	Cause	Remedy
Steady....	Regular......	Normal conditions.	None necessary.
Oscillating needle.	Irregular....	Loose contact in battery circuit—Leakage of secondary current—Short circuit or exhausted cells	Tighten connections—See that timer contact is made evenly—Eliminate leakage.
Uniform or gradual drop.	Regular......	Normal deterioration of battery.	None required.
Abnormal drop.	High........	Rapid deterioration of battery because of short circuit at plug or in battery box—Improper adjustment of coil-vibrator or spark, plug gaps, latter being too narrow—One or two exhausted cells.	Eliminate short circuit — Readjust vibrator and spark gaps—Remove exhausted cells.
Normal...	Low..........	Poor contact in timer, vibrator, or connections—Short circuiting of cells.	Clean contacts, eliminating effects of corrosion or wear.
Normal...	High........	Sooted spark plug—Gaps at vibrator or spark plug too small — Decreased coil efficiency.	Clean spark plugs—Increase width of gaps — Readjust tension of vibrator spring.
Normal...	Irregular....	Poor timer contact...........	Fix timer.
Normal...	Zero.........	Broken ground wire...........	Put in new wire.
Zero......	Zero........	Broken wire between coil and battery or broken battery connections.	Put in new wire.

IGNITION—TIMING. In timing the ignition of a motor one should base his operations on one particular cylinder, and this should be the most accessible one. Let it be assumed that a mechanic is required to test or correct the timing of a four-cylinder, four-cycle vertical engine. He would have to know the order in which the cylinders fired, and how to find the firing center of No. 1 cylinder. As the operation of the valves on most motors may be readily seen, the firing center and the order in which the cylinders fire can be easily learned from the action of either set. For instance, if on turning the motor over slowly the intake valve of No. 1 cylinder opens and closes, then that of No. 3 cylinder, and following No. 3 that of No. 4 operates, the mechanic need go no further, for he knows that the engine fires 1-3-4-2. The exhaust valves, of course, may be used in the same way. However, if the valves are entirely enclosed, as on the Winton cars, open the priming or relief cocks, and beginning with cylinder No. 1 note the order in which the air is forced out through the cocks. There are two rules for finding which cylinder is on its firing center, that are based on the action of the valves; these are as follows: When an exhaust valve is open the following cylinder is about to fire. When an intake valve is open the previous cylinder is about to fire. One very simple method of finding the firing center of a cylinder is to open the priming cocks of all the cylinders but one,

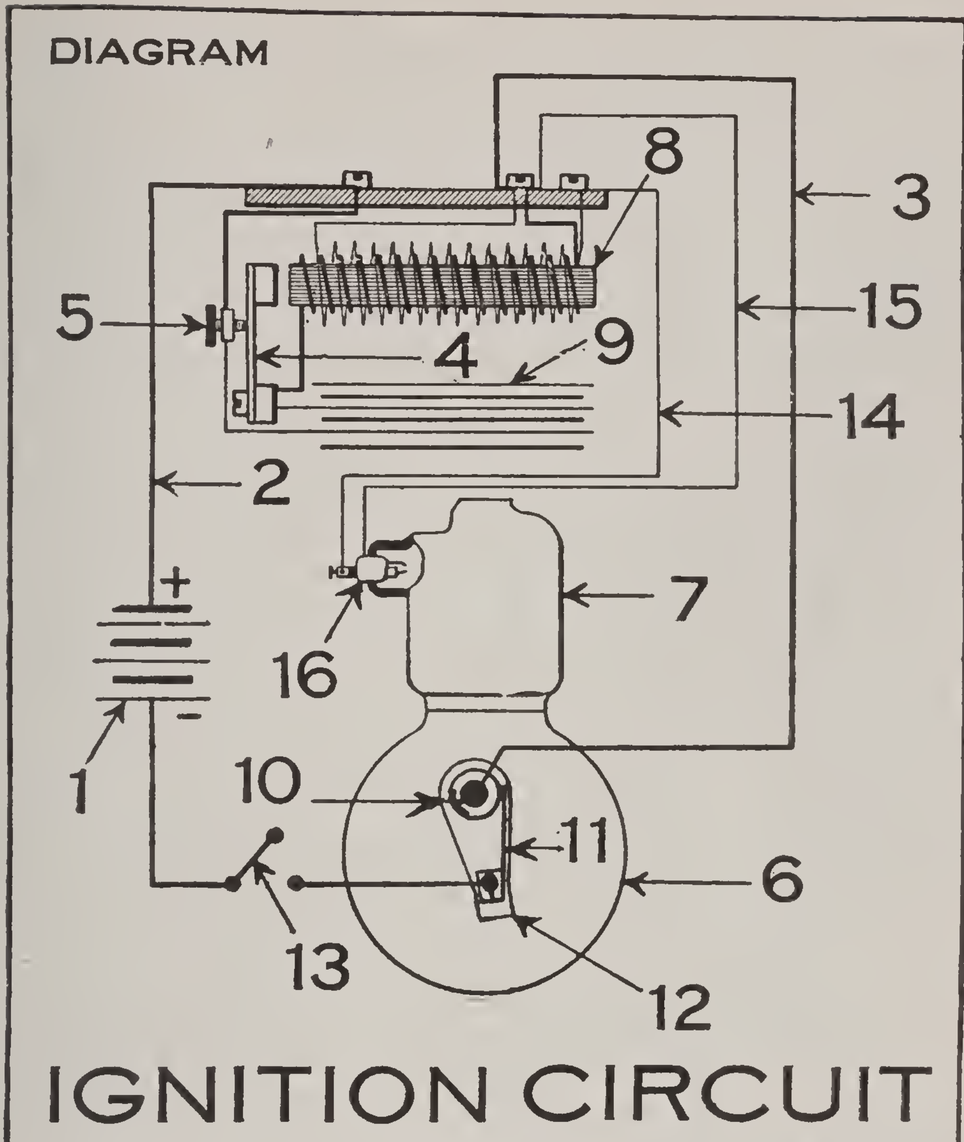


Fig. 167

1—Battery.	9—Condenser.
2 and 3—Primary wires.	10—Commutator.
4—Vibrator.	11—Contact maker.
5—Contact screw.	12—Commutator case.
6—Crank case.	13—Switch.
7—Cylinder.	14 and 15—Secondary wires.
8—Induction coil.	16—Spark plug.

turn the motor over slowly till compression is encountered, open the cock, insert a stiff wire till it rests on the piston head, then carefully bring the piston to the top of its stroke. The

cylinder will then be on its firing center. When the firing center, and the order in which the cylinders fire are known, all that remains to be done in timing an engine is to set the revolving segment of the commutator or distributor so that a spark will occur in the proper cylinder when the spark control lever is advanced about one-third or, with the spark control lever fully retarded, and the piston about ½ to 1 inch down on the explosion stroke, set the segment so that it just begins to make contact.

Ignition—Wiring Diagrams. Fig. 167 illustrates the ignition circuit of a single cylinder motor, showing plainly the battery, coil and commutator connections. A reference table accompanies Fig. 167, giving the names of the various parts shown in the drawing of the ignition circuit.

Fig. 168 shows connections for four cylinder ignition in which the timing of the spark is controlled by the rotation of a single timer V around shaft E.

This varies the point in the engine cycle at which the cam E acts on each spring. Wear in the timer is taken up by adjusting the platinum points. Either storage batteries or dry cells may be used in this system as desired.

The objections to this system have been that the arrangement of contact points often gets out of order, owing to their delicacy of adjustment, the inaccessibility of the timer, the tendency of the springs to break, and the ease with which

the contact may become broken by means of oil or dirt. This system is classed as a mechanical make and break system, owing to the fact that the spark is caused by the abrupt mechanical action of the contact spring. Another system known as the multiple vibrator coil ignition system is illustrated in Figs. 169, 170, 171, 172 and 173.

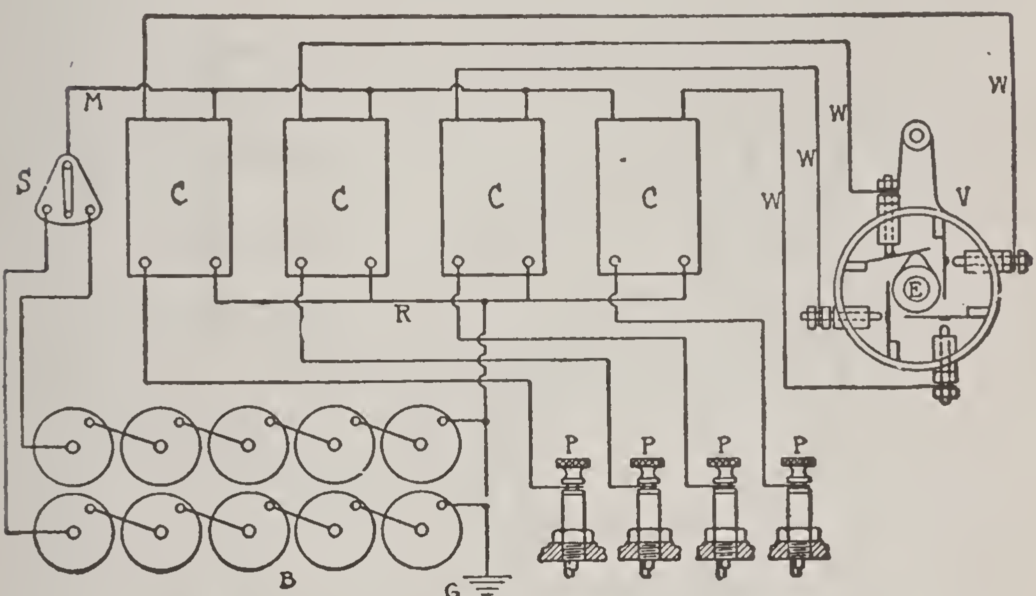


Fig. 168
Diagram of Connections for Four-Cylinder Ignition With Four Coils and One Timer

In this system each coil has its own vibrator, which depends for its action upon the electrical make-and-break instead of the mechanical timer as shown in Fig. 168. Referring to Fig. 169, the timer consists of an insulated cylinder I, loosely carried by a sleeve on the two to one shaft. On the inside of this cylinder are disposed at regular intervals the contact segments K, K, K, K, and fixed to the shaft is the moving

brush E, which makes a wiping contact successively with each of the fixed segments.

The electrical connections in this system are as follows: When the brush is rotated into contact with segment K, the circuit is through wire

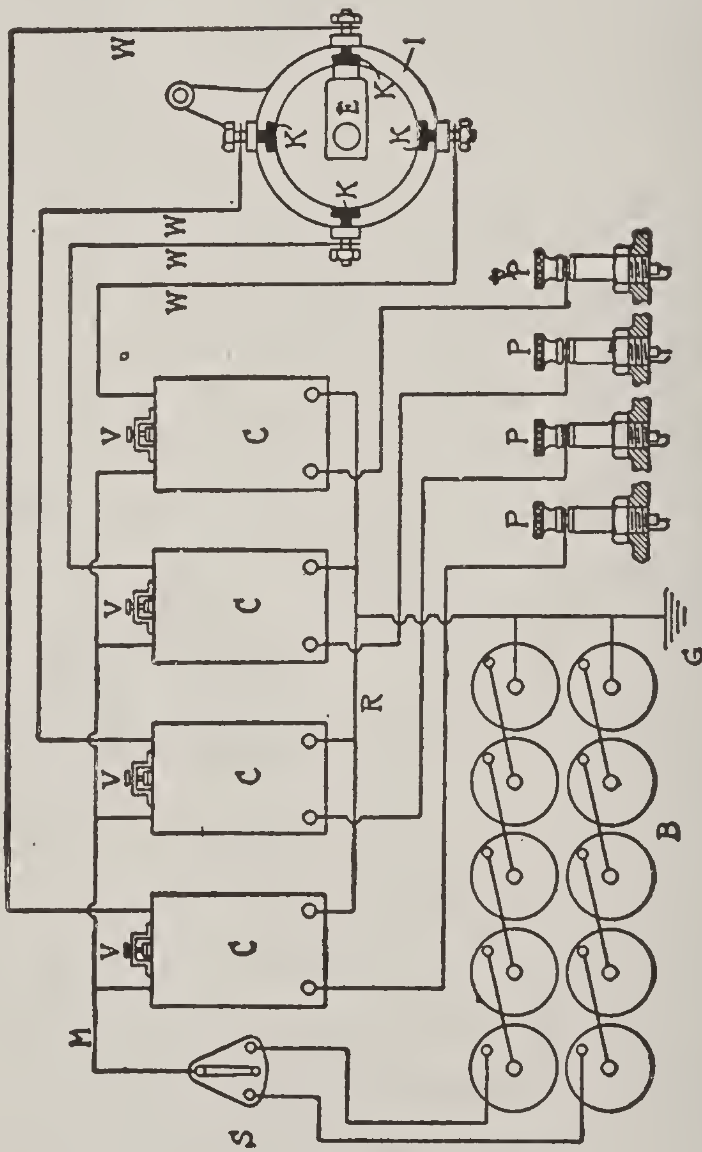


Fig. 169
Diagram of Connection for Four-Cylinder Ignition With Four Vibrator Coils

W to contact screw of the vibrator of coil C, thence into the vibrator spring and into one end of the primary winding of the coil, out at the other end thereof to the common wire M, through the switch S, and through one or other

of the two battery sets to the engine frame, thence through the two to one shaft, and through the timer brush to the starting point, the induced secondary discharge giving rise to a spark at plug P. When the contact is made between the brush E, and the segments K, K and K respectively, coils C, C and C respectively act, producing successions of sparks in plugs P, P and P. The rapidity and power of the sparks

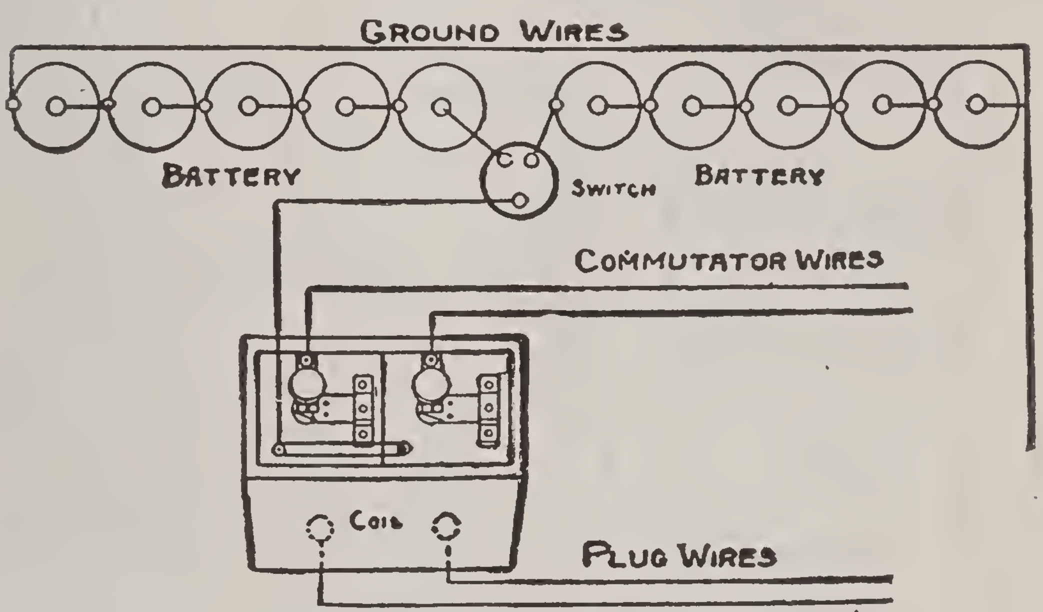


Fig. 170
Wiring Diagram of Two-Cylinder Dash Coil

produced by the several coils largely depend upon the adjustment of their respective vibrators. If a vibrator is adjusted too lightly, it may break the circuit before the coil is charged adequately to produce a spark of full power, and if too stiffly adjusted it may hold contact until the coil has been charged for too long a period, thus causing a waste of current, although producing a good spark. Incorrect ad-

justments may also cause differences in the amount of power developed in the several cylinders, causing a generally unsatisfactory action of the motor. The advantages of this system over the mechanical make-and-break vibrator are: The absence of delicate platinum or steel springs; and that the coils may be mounted on the dash, where they are easy of access.

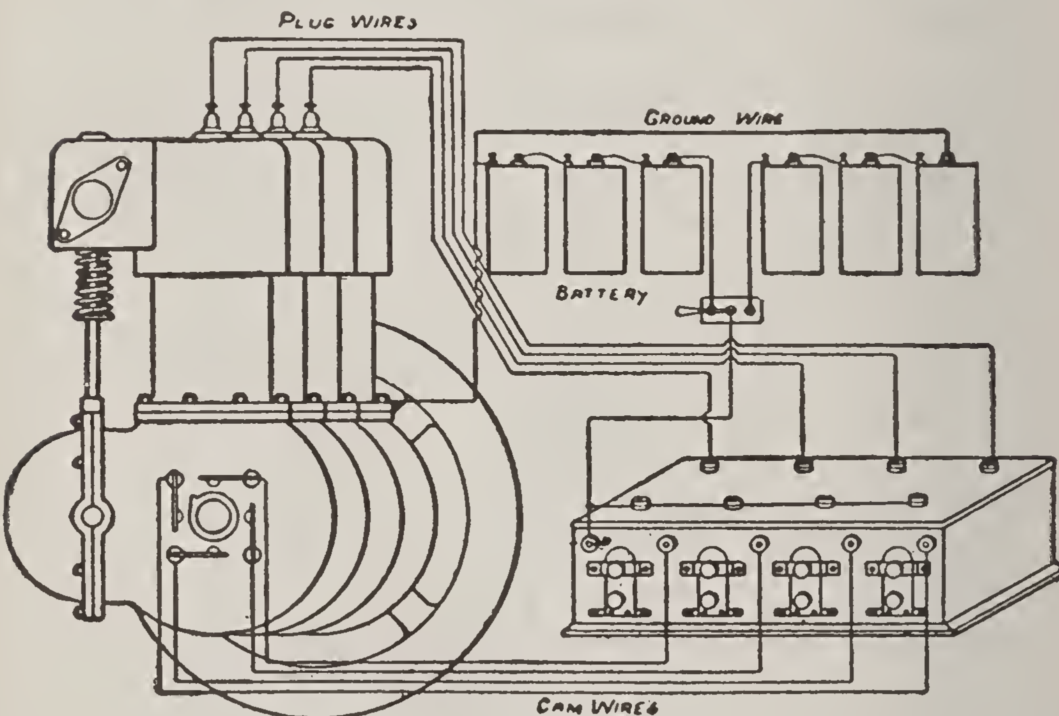


Fig. 171
Wiring Diagram of a Four-Cylinder Box Coil

In order to obviate lack of uniformity between the sparks in the different cylinders, and at the same time to save some outlay in coils and reduce the necessary wiring, the single coil distributor system, diagrammatically illustrated in Fig. 173, is employed, the distributer being merely a device designed to direct the discharge of the single coil to the spark plug of each cyl-

inder in rotation. The timer T is of the brush and segment type, driven by or from the two to one shaft. It is provided with four equally spaced contact segments K, K,, K, K, which instead of being wired to separate coils, are all electrically connected by a metal ring, which is connected to one primary terminal of the single vibrator coil. Distributer D is also mounted and driven by the two to one shaft.

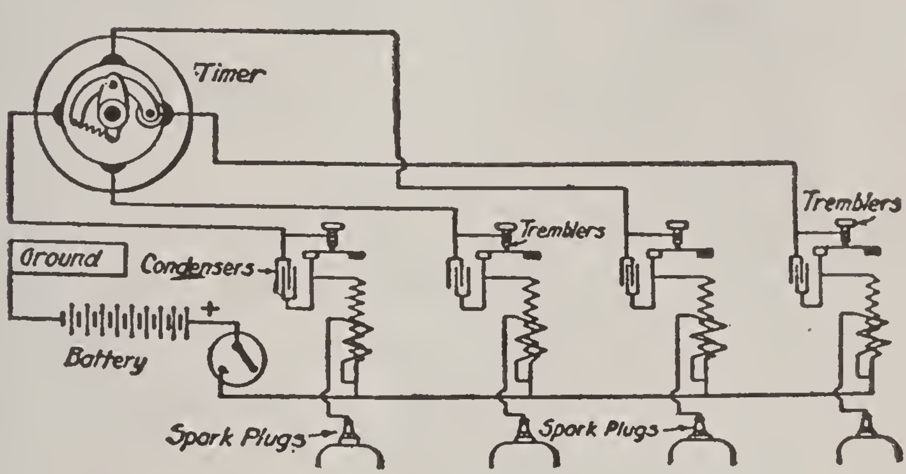


Fig. 172
Diagram of Wiring of a Four-Unit Vibrator Coil

For clearness this distributer is shown separately, although it is generally made integral with the timer. It consists of an insulated shell carrying four metallic segments L, L, L, L. Within is a continuous metallic ring R. The rotating arm M is insulated from the two to one shaft, and carries at its outer end a brush, arranged to bear upon the segments and ring R, or to pass in very close proximity thereto. Segments L connected by wires W to plugs P. One of the secondary terminals of coil C is connected

to ring R, and the other to the engine frame or ground.

The action is as follows:

Suppose that the brushes of the timer and distributer are in the position shown, the path

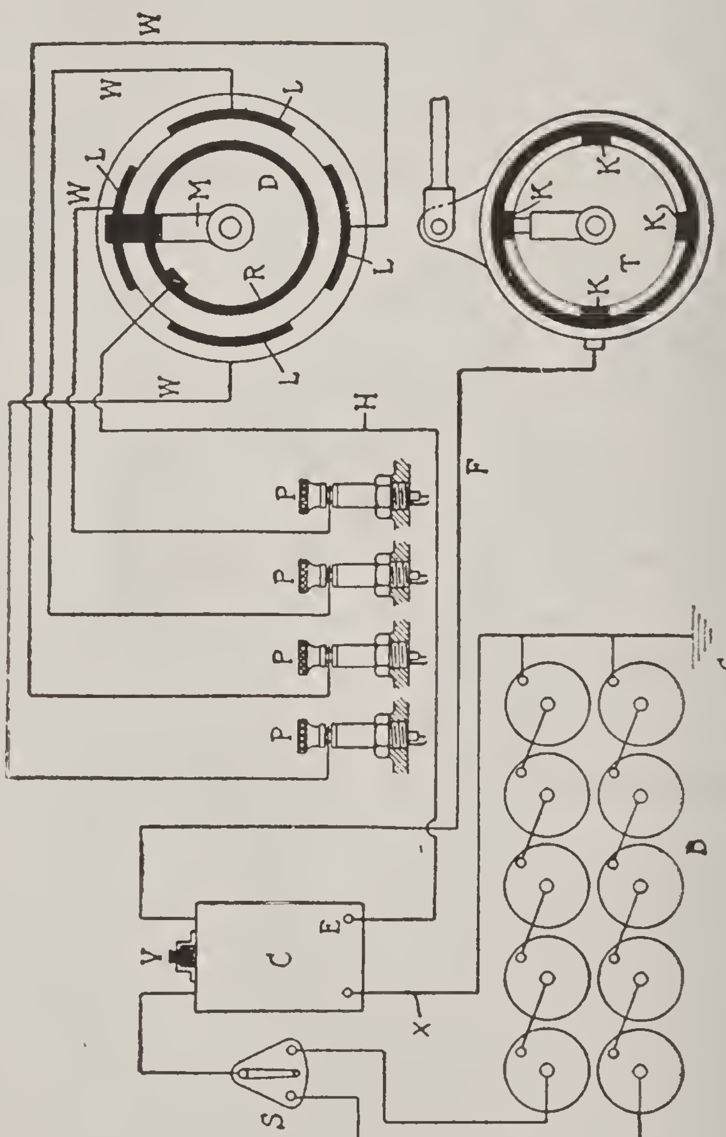


Fig. 173
Four-Cylinder Ignition With Single Vibrator Coil and High Tension Distributer

of the primary current will then be as follows: From segment K the current will flow through the common ring along wire F to one primary terminal to the coil box C, through the vibrator contact screw and vibrator spring V, through

the primary winding, out at the other primary terminal of the coil, through the switch S, through one or the other of the batteries B into the engine frame, through the secondary shaft and timer brush to the starting point. The course of the secondary discharge will be as follows: From secondary coil terminal E, through wire H to the common ring R, of the distributer, through the brush carried by the revolving insulated arm to segment L, out through wire W to the insulated terminal of plug P, through the air gap of the plug to the engine frame, up through wire X, from the engine to the other secondary coil terminal, and thence through the secondary winding to the starting point. All four cylinders are thus sparked in rotation from a single coil, and as the vibrator of this coil determines the discharge in each one of the four cylinders, ignition is uniform in point of time. This is termed synchronous ignition. The timing of the spark is changed by rotating the timer and distributer around the shaft, the length of the segments being sufficient to allow of this, and still maintain contact with the brush, even at the extremes of spark advance and retardation. The main disadvantage connected with the single vibrator high tension system is that the high tension current is brought into close proximity to "ground" in the distributer, and if the insulation becomes impaired it may escape there, or at times jump to the wrong segment and

spark the wrong cylinder. In any single vibrator system there is almost constant work demanded of this vibrator, and other things being equal it naturally wears several times as fast as a vibrator sparking but one cylinder.

In all jump-spark systems of ignition in which the circuit is interrupted between platinum contacts, the condenser plays a very essential role in reducing the burning of these contacts, although its chief office is in increasing the abruptness with which the current is interrupted, and hence augmenting the discharge pressure.

When to Retard the Ignition. Always reretard the ignition before starting the motor, and take great care that the ignition is retarded and not by mistake advanced. Some cars are fitted with a device which prevents the starting crank being turned unless the spark is retarded. If it is not clear as to which way to move the ignition lever to retard the ignition, move the commutator in the same direction as the camshaft rotates.

As soon as the motor slows a little when going uphill, retarding the spark enables more power to be obtained from the motor at the slow speed, that is to say, if the spark is not retarded the motor will go slower than if it is retarded. Do not retard the lever to the utmost under these conditions; on the contrary, retard the lever to such a point that the knocking (due to the wrong position) ceases.

Retarding the spark causes the maximum

The following description and wiring diagram of Jump Spark Ignition Systems were copied from the Nov. 3, 1910, issue of "Motor Age," and show in a graphic manner the connections and relative arrangement of the leading features:

"In Fig. 173a a wiring diagram is given, representing the relative arrangement of the features of four popular types of jump spark ignition systems, including a single battery system, a single high-tension magneto system, a dual low-tension magneto system, and a double ignition system with a high-tension magneto, and a battery, coil and timer. In the single battery system, when the switch S is closed, current flows from the battery to the four-unit vibrating coils, on through one of the coils, and one of the primary wires L1, L2, L3, or L4, according to the position of the revolving segment of the timer, and then returns to the battery through the ground wire G. The secondary current generated in the coils every time a primary circuit is broken passes through one of the respective wires H1, H2, H3, or H4, to the spark plug in the cylinder. In the single high-tension magneto system, both the primary and secondary currents are generated in the high-tension magneto and pass through the cables M1, M2, M3 or M4 to the spark plugs.

The features of the dual system include a low-tension magneto and battery as sources of current, a non-vibrating induction coil and one set of plugs. In this system, when the switch on the coil is on the battery side B, the current flows from the positive pole of the battery through the wire C to the coil, and then to the circuit breaker-box B1 on the magneto through wire P1, where, when connection is made, the current flows back to the coil-box through P2 and returns to the battery through C1. The primary current is broken in the circuit-breaking box B1, generating the induced currents in the non-vibrating coil and these high-tension currents flow to the distributor D of the magneto through the heavily-insulated wire P, and then pass on to the spark plugs through one of the wires W1, W2, W3, and W4. When the battery switch is turned to the magneto side M the primary current flows from the magneto to the coil through the wire P1, and when the connection is made in the circuit-breaker box B1 it returns through wire P3. And when the circuit is broken in the breaker-box the high-tension currents induced in the coil go to the distributor and on to the spark plugs just as when the battery was employed.

In a double ignition system there are two independent ignition systems. In this diagram the battery system above described would comprise one of the systems, and the high-tension magneto system the other. The switch S1 on the coil box of the battery system and the wires MG and GG leading to the magneto are merely employed to short circuit the primary current of the magneto and prevent the induction of the high-tension currents required at the spark plugs when it is desired to cut this system out of action. The double system requires two sets of plugs, one for each system as indicated."

CAUSES OF TROUBLE

No explosions—
1—Switch off
2—Batteries exhausted
3—Battery to switch wires short-circuited
4—Switch out of order
5—Magneto short-circuited
6—Broken battery connection
7—Batteries nearly exhausted

Regular miss-firing, one or more cylinders—
8—Spark plugs sooted
9—Insulation cracked
10—High-tension cables short-circuited
11—Timer to coil wires short-circuited
12—Vibrators out of adjustment
13—Magneto distributor contacts worn
14—Spark plug points out of adjustment

Irregular miss-firing, one or more cylinders—
15—Batteries weak
16—Defective wiring
17—Dirt or loose metal in timer
18—Loose connections

REMEDIES

No explosions—
1—Turn on switch
2—Recharge or replace batteries
3—Test with fresh wire
4—Attach or shunt wires around switch
5—Remove wire to switch, crank motor
6—Tighten all connections
7—Readjust vibrators on coils

Regular miss-firing, one or more cylinders—
8—Remove and clean
9—Replace with good plug
10—Separate from metal of engine
11—Rewire
12—Readjust and clean points
13—Renew brushes or stretch springs
14—Space $\frac{1}{32}$ inch

Irregular miss-firing, one or more cylinders—
15—Recharge or renew battery
16—Insulate or renew wiring
17—Clean timer
18—Find and tighten

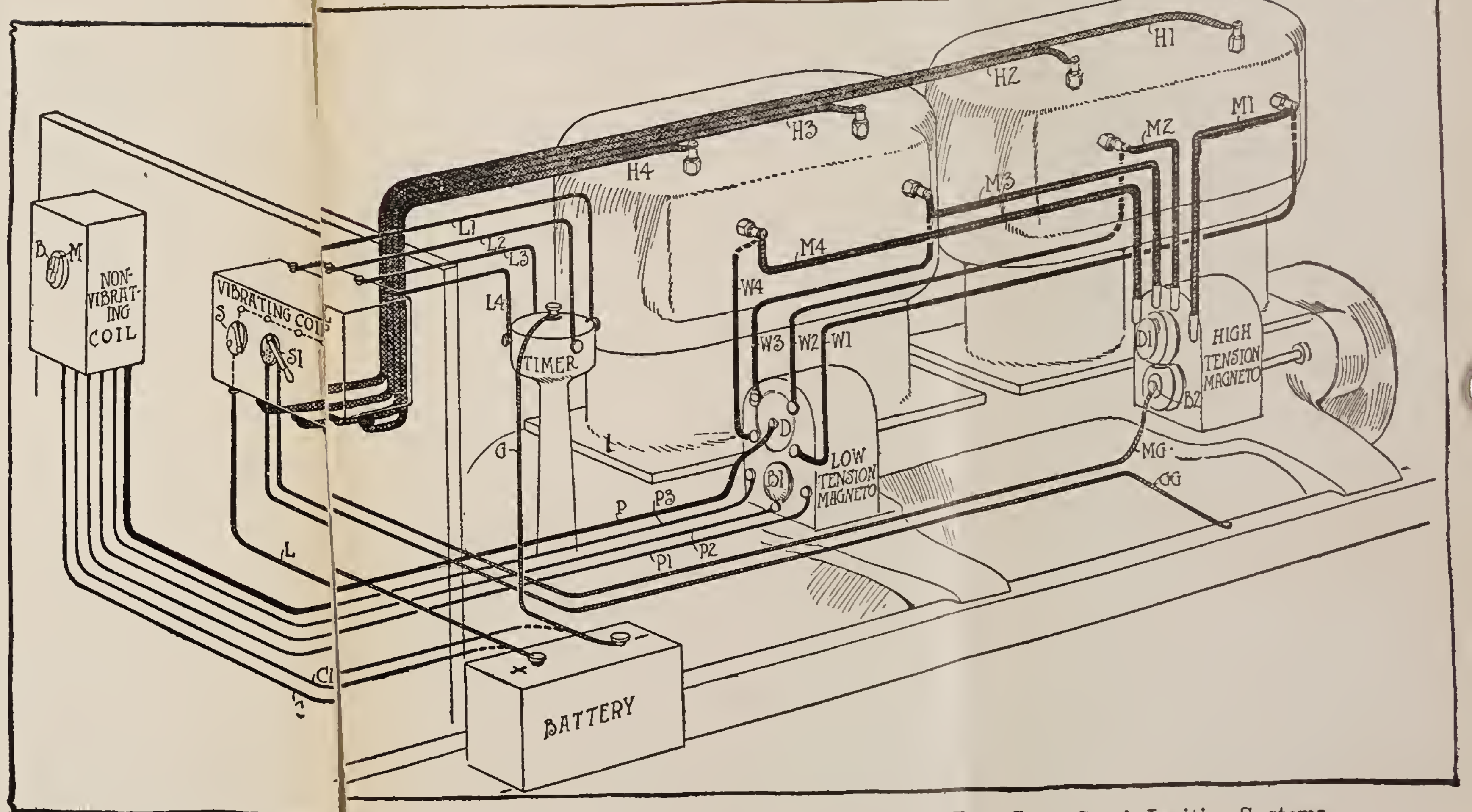


Fig. 173a—Wiring Diagram Showing Relative Arrangement of Features of Four Jump-Spark Ignition Systems

The following description and wiring [illegible] 1910, [illegible] "[illegible]," and [illegible] leading features:

[illegible]

pressure of the explosion to occur at the best part of the stroke, or, rather, the mean pressure of the explosion stroke will be lower if the best point of ignition by retarding is not found. This is a matter of some skill and practice.

To slow the motor, cut off as much mixture as the throttle allows, then slow the motor still further by retarding the spark, but on no account retard the spark when the throttle is full open (for the purpose of slowing the motor), as the motor will merely discharge a quantity of flame at a white heat over the stem of the exhaust valve, burning it, softening it, and making it scale.

When to Advance the Ignition. With too early ignition the pressure upon the piston becomes excessive and without any adequate return of useful work or energy. If the ignition be retarded too much, the maximum explosive pressure occurs too late during the working or power stroke of the piston, and the combustion of the gases is not complete when the exhaust-valve opens. Greater motor speed requires an early ignition of the charge, but greater power calls for late or retarded ignition.

The reason for advancing the spark when fast running is required, is that the explosion or ignition of the charge is not instantaneous as may be supposed, but requires a brief interval of time for its completion.

It may be well to explain without entering

into theoretical details, that when a motor is running at normal speed, the ignition-device is so set that ignition takes place before the piston reaches the end of its stroke. The later the ignition takes place the slower the speed of the motor and consequently the less power it will develop. If, however, in starting the motor the ignition-device were set to operate before the piston reached the end of its stroke, backfiring would occur, resulting in a reversal of the operation of the motor and possibly in injury to the operator.

IGNITION TROUBLES—REMEDIES FOR. Trouble may occur from the cam or commutator not being properly adjusted. The contact-screw of the induction coil vibrator may be loose.

The vibrator or trembler of the coil may not be properly adjusted.

To adjust the vibrator, turn the motor crank until the contact is closed, throw in the switch and listen for a good clear buzz from the vibrator. Do not allow it to buzz slowly but fast, until it makes a singing sound like a bumble bee, then turn the crank several times and again listen for the buzz. Sometimes the vibrator will buzz, but it will not buzz when the motor is running fast and the motor misfires; this is probably due to the fact that the adjusting screw has made the tension of the spring too strong, and when a quick contact is made it does not have time to vibrate properly. Expe-

rience is the only teacher for properly adjusting the vibrator of an induction coil.

Many troubles arise from faulty or defective insulation.

A wire placed too close to an exhaust-pipe invariably fails after a time, owing to the insulation becoming burnt by the heat of the pipe.

A loose wire hanging against a sharp edge will invariably chafe through in course of time.

If the insulation of the coil breaks down it cannot be repaired on the road, it should be returned to the makers. A slight ticking is usually audible inside the coil when this occurs.

All wires where joined together should be carefully soldered, the joints being afterwards insulated with rubber or prepared tape. Never make a joint in the secondary wires. See that all terminals are tightly screwed up. When connecting insulated wire, the insulation must be removed, so that only the bare wire is attached. Wires sometimes become broken, and being loose make only a partial contact.

Battery terminals frequently become corroded; they should be covered with vaseline, and require periodical cleaning. See that all connections at the battery are clean and bright.

The porcelain of the spark plug may be cracked and the current jumping across the fracture. The points may be sooty and require cleaning. They may be touching and require separating, or they may be too far apart. The usual distance between the points is about one

thirty-second of an inch, which is approximately the thickness of a heavy business card.

Clean all oil and dirt from the commutator. Most commutators are so placed as to give the maximum possible opportunity to collect oil and dirt. They should always be provided with a cover.

In course of time dry or storage batteries will become weak or discharged. Always carry an extra set.

Spanners, oil-cans, tire-pumps, etc., have been known to get on the top of the batteries, thereby connecting the terminals together and causing a short-circuit.

The platinum contacts of the coil may become corroded. They should be cleaned with a small piece of emery cloth or sandpaper.

The platinum points on the trembler may become loose. They should be riveted up with a small hammer.

It frequently happens that oil and dirt accumulate on the platinum contacts, which interrupt the free flow of the current. Care should be taken, therefore, that they are always perfectly clean.

Indicator. An indicator consists of a small cylinder within which works a piston under the tension of a helical spring of predetermined strength. The rod attached to the piston carries a pivoted arm which works on a horizontal lever. This lever carries a pencil bearing against a drum. This drum is so arranged

with a spring that it may be partially rotated by the pull on an attached string. A sheet of paper is wound on the drum and held in place by spring clips. The pressure in the cylinder acting on the spring causes the pencil to mark the paper, the indicator card or diagram being traced by the forward and backward movement

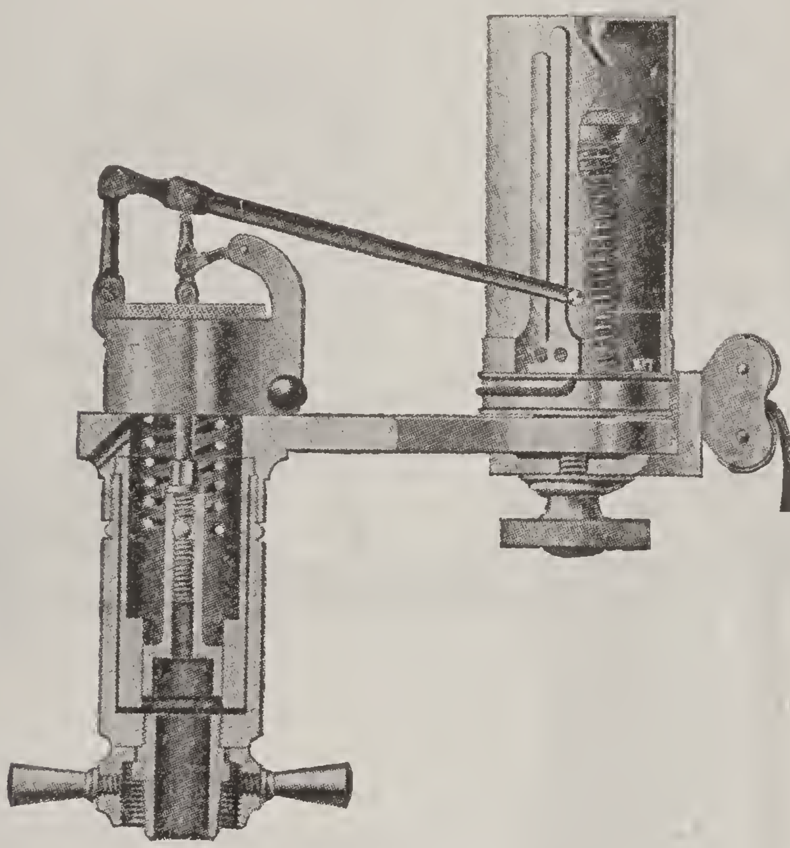


Fig. 174

of the drum. Fig. 174 is a semi-sectional view of a Crosby indicator with small piston in place for explosive motor work. The pencil arm is of extra strength to withstand the shock due to the explosive pressure exerted upon the piston. Fig. 175 shows the new Crosby indicator designed for taking continuous diagrams. The

drum is designed to use a roll of paper 2 inches wide and 12 feet long, upon which is made in the operation of the indicator a series of dia-

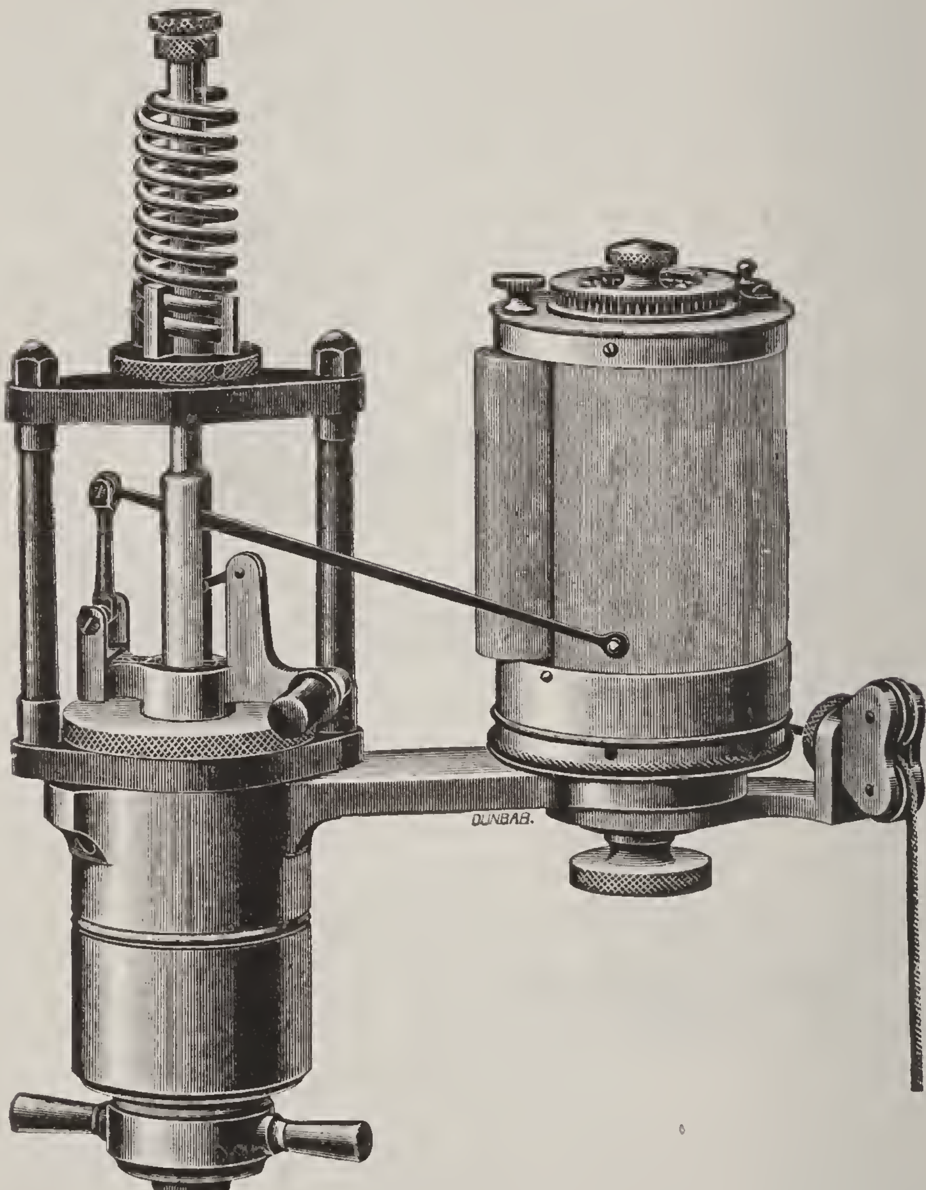


Fig. 175

grams. In the center of, and concentric with the drum is a cylinder upon which the paper is wound as it is used. When the roll is exhausted, the cylinder can be withdrawn

through an opening in the top of the drum, and the paper easily detached. Above the cylinder is a knurled head loosely attached to the drum spindle which may be adjusted to take continuous diagrams, varying in number from 6 to 100 per foot of paper. Fig. 176 shows the Tabor indicator. The view of the cylinder being transparent, the small piston may be seen inside. The spring is placed outside of the cylinder in order that the hot gases from the engine will not affect its temper, and thereby change its tension.

All indicators of this type, employing a pressure piston and spring, require careful calibration where extreme accuracy is essential. On account of the inertia of the piston and pencil mechanism, and that of the oscillating drum, engines of very high speed cannot be indicated by the forms of indicator just described. They have been found to be reasonably accurate at speeds as high as 500 revolutions per minute, although at this speed they can be used successfully only by experienced hands.

Indicators for High Speed. To overcome this objection and to be able to indicate engines of speeds as high as 2,000 revolutions per minute or more, indicators employing a beam of light thrown upon a sensitive photographic plate are now used. In this case a small mirror is caused to move in two planes at right angles to each other, one movement being produced by the motion of the piston, the other by the

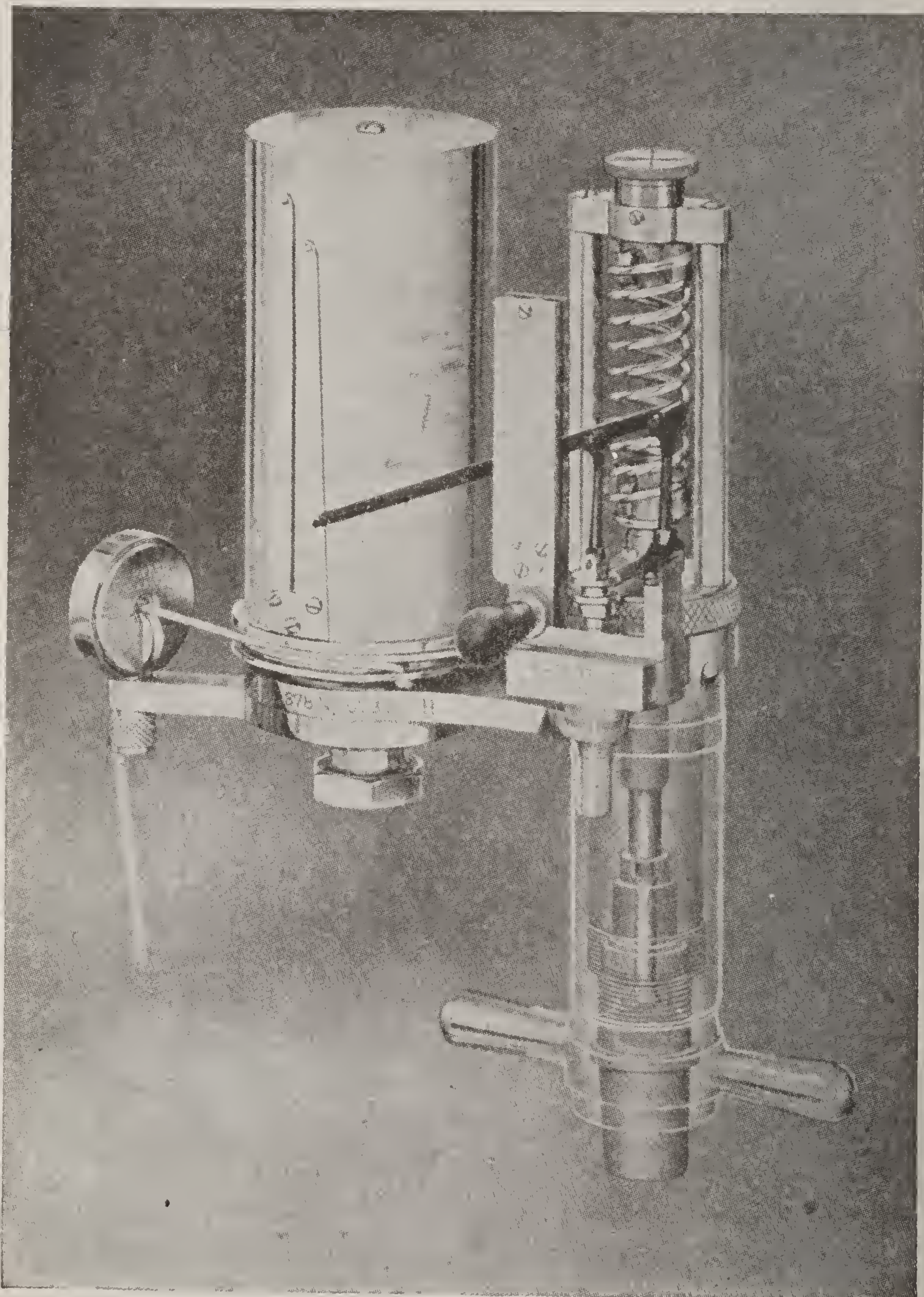


Fig. 176
Tabor Indicator With Outside Spring

pressure, which is transmitted through a thin steel diaphragm. The angular motion of the mirror is so small, and the parts so light that the effect of inertia becomes practically negligible.

Fig. 177 shows the general appearance, and Fig. 178 two sections of one type of the indicator referred to. This instrument is called the Hospitalier-Carpenter Manograph and is manufactured in Paris.

Some makers manufacture special heavy in-

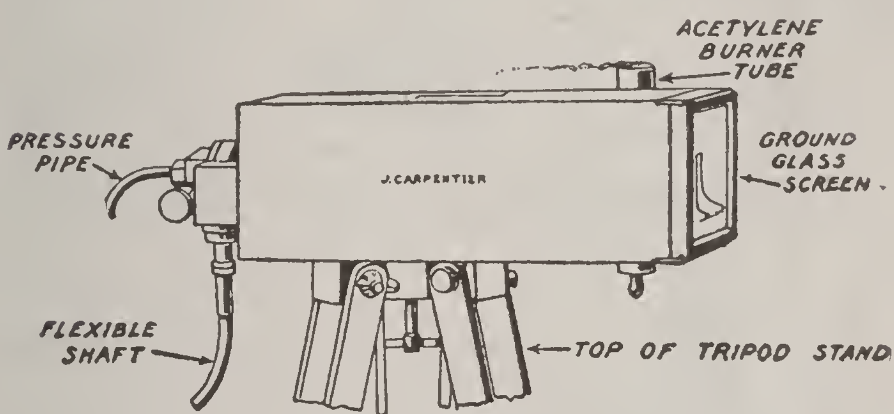


Fig. 177

dicators with ¼-inch pistons to suit the pressures involved in gas engine indication. Springs from 80 pounds to 200 pounds scale are very efficient in recording expansion, combustion and compression lines, as these effects are all high pressure. If the low pressure lines, such as the suction and exhaust, do not show up to advantage when taken with high scale springs, low scale springs of from 10 lbs. to 30 lbs. may be used for obtaining these lines.

Indicator Diagrams. Fig. 179 shows a char-

acteristic diagram from a four cycle engine. On the forward stroke of the engine the piston draws into the cylinder a charge of explosive mixture, the pencil of the indicator tracing the line A-B. It will be seen that this line drops slightly below the atmospheric line A-F. This slight drop is due to the partial vacuum produced within the cylinder during the "suction

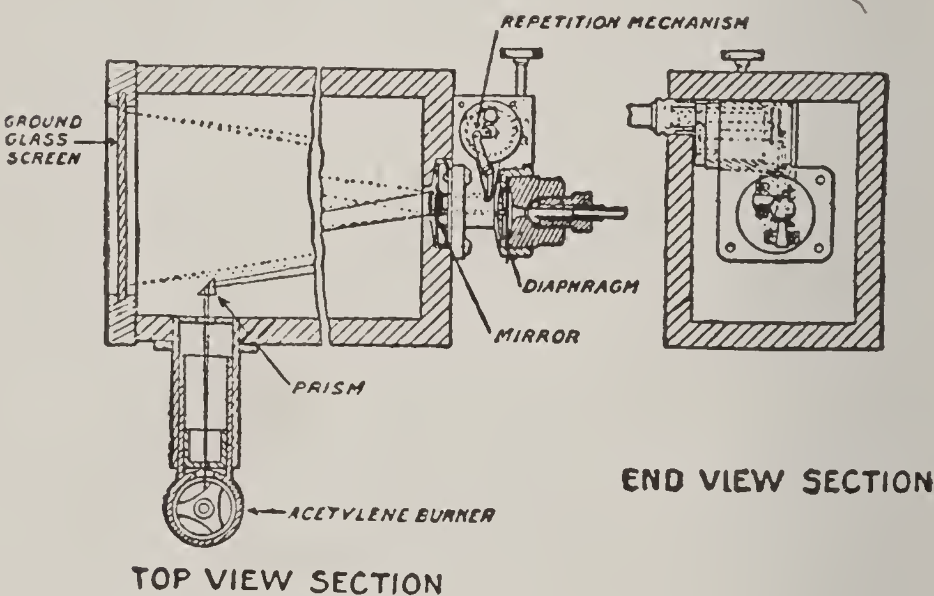


Fig. 178
High Speed Engine Indicator

stroke" of the engine. From point B, the piston returns to its original position compressing the mixture in the clearance space, the indicator tracing the line B-C, which is known as the compression curve. At this point ignition takes place with a sudden increase in pressure. the indicator tracing the line C-D, which is nearly vertical. On the next or third stroke, the gases are expanded to point E. at which time the exhaust valve opens, the indicator having traced

the line D-E which is known as the expansion curve. At E there is a drop in pressure as the gases issue from the exhaust port and from F to A the gases are swept from the cylinder which causes a line to be drawn by the indicator slightly above the atmospheric line A-F, as shown. This completes the cycle. The vertical distance from the atmospheric line to point C is proportioned to the compression pressure above atmosphere; the distance to point D is

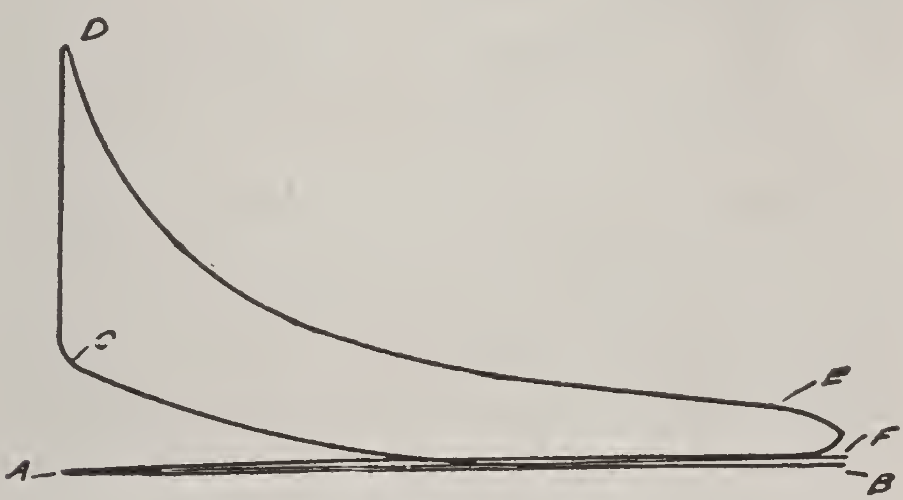


Fig. 179

proportional to the explosion or maximum pressure, and the distance to point E is proportional to the release pressure.

Figure 180 shows a card from a two-port two-cycle gas engine. It will be noticed that the suction and exhaust lines are absent, the suction stroke being completed in an enclosed crank case, or a separate cylinder or pump. The exhaust takes place at A and requires about one-tenth of the stroke. The exhaust and inlet

ports are covered and uncovered by the piston and are definitely fixed points.

Figure 181 shows a very good diagram, where combustion is very nearly complete, the mixture of air and gas being practically correct.

Fig. 180

The ignition line points slightly to the right at the top, and is nearly perpendicular. The exhaust is shown to open at the right time about ninety degrees of the stroke. The suction and exhaust lines run very near the atmospheric

Fig. 181

line, thereby denoting correctly proportioned inlet, and exhaust valves, and passages for same.

INDICATED HORSE POWER. The thermal or heat efficiency of an explosive motor may be deter-

mined from an indicator diagram, which gives a representation of the internal conditions throughout the entire cycle of operations. The diagram tells many things essential to be known.

It gives the initial explosive pressure, or the pressure a moment after ignition has taken place. It shows whether the volume of the charge is diminished during the period of admission. It gives the point of ignition, when the ignition is complete, and when expansion begins. It indicates the pressure of expansion during the working stroke. It gives the terminal pressure when the exhaust is opened. It shows the rapidity of the exhaust. It indicates the back-pressure on the piston, due to the exhaust. It shows the point of opening of the exhaust. It gives the mean power used in driving the motor. It also indicates any leakage of valves or piston.

The usual method of ascertaining the area of an indicator diagram is by means of an instrument known as a planimeter, which is used to calculate the area of any irregular surface, by moving a tracing point attached to the instrument over the entire irregular boundary line of the figure.

But for the purpose of ascertaining the horsepower of a motor it will be sufficiently accurate to illustrate the principles involved, to calculate the area of the diagram by means of ordinates or vertical measurements.

The upper drawing in Fig. 182 represents a card taken from a motor of 4 inches bore and 6 inches stroke, with a speed of 900 revolutions per minute, and under a full load. The diagram is divided into 12 parts as shown by vertical lines, the lengths of which are in terms of

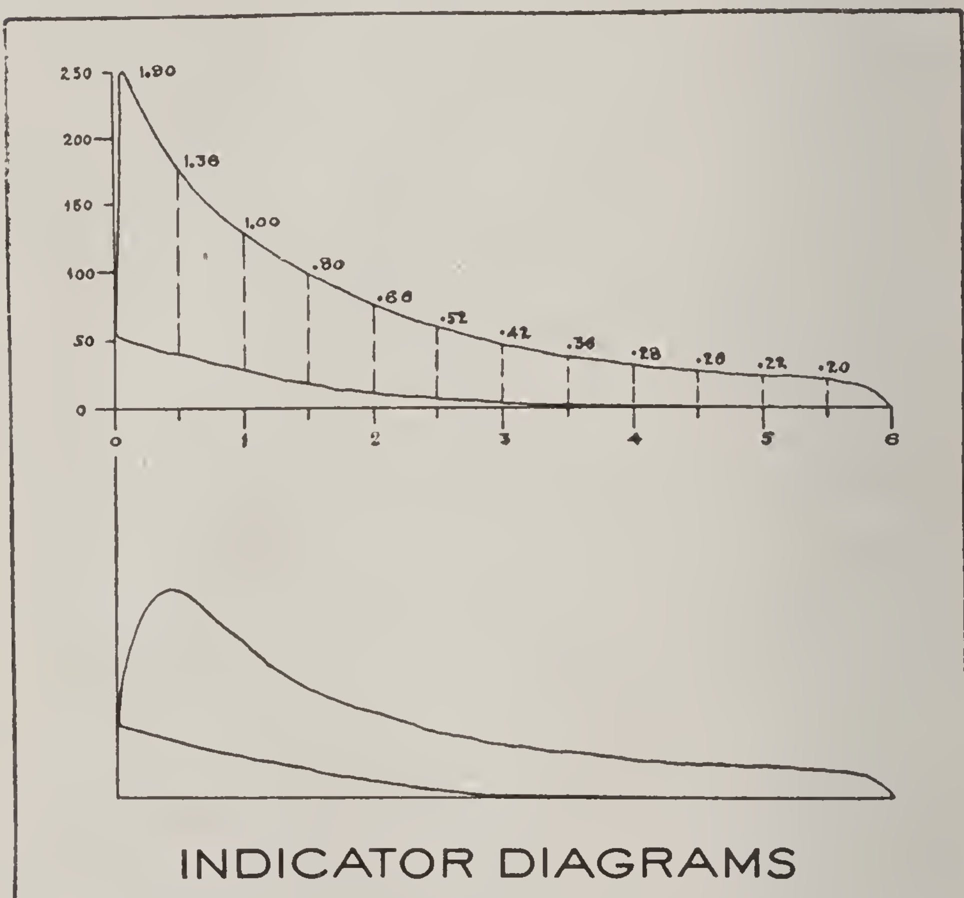


Fig. 182

the spring, which is 100. Then 1.90 + 1.36 + 1.00, etc., divided by 12, equals 0.665 as the average height of the diagram. Its length is assumed to be 6 inches, therefore the area of the card is approximately 3.99 square inches. As the initial explosive force from the diagram is 250 pounds per square inch, and a 100 indicator

spring used, the height of the card is 250 divided by 100, which equals $2\frac{1}{2}$ inches. The mean effective pressure on the piston in pounds per square inch will therefore be equal to the area of the diagram 3.99, divided by the area of the whole card, which is $2\frac{1}{2} \times 6$, equals 15, and multiplied by 250, the initial explosive force, or 3.99×250, and divided by 15, equals 66.5 pounds per square inch as the mean effective pressure required.

From this the indicated horsepower of the motor can readily be found as follows:

Let M.P be the mean effective pressure in pounds per square inch, A the area of the cylinder in square inches, S the stroke of the piston in inches, N the number of explosions per minute, and H.P the indicated horsepower, then

$$\text{H.P} = \frac{\text{M.P} \times \text{A} \times \text{S} \times \text{N}}{396{,}000}$$

$$= \frac{66.5 \times 12.56 \times 6 \times 450}{396{,}000} = 5.69$$

as the required indicated horsepower of the motor. The indicated horsepower of any motor will always be greater than that obtained from a brake test, as it simply represents the actual thermo-dynamic (heat-pressure) conditions within the cylinder, and takes no account of friction and other external losses.

The lower drawing in Fig. 182 is a card taken from the same motor running under half load.

Induction Coil. The form of coil generally used on gasoline cars is known as the jump-spark coil. It is of two types, one known as a plain or single jump-spark, the other as a vibrator or trembler coil.

A jump-spark coil consists essentially of a bundle of soft iron wire, known as the core, over which are wound several layers of coarse or large size insulated copper wire, called the primary winding. Over this are again wound a great many thousand turns of very fine or small wire, known as the secondary winding.

Inertia. Inertia is that property of a body by which it tends to continue in the state of rest or motion in which it may be placed, until acted upon by some force. As used by the non-technical, it is almost universally employed in the former sense, i. e., that of the resistance which a body offers against a change in its position, an inert body usually being intended, so that the definition is perfectly correct so far as it goes. The popular impression is that only inert bodies have inertia, it being likewise generally thought that a moving body is possessed of momentum alone, whereas an object at rest is possessed of inertia, and the same object in movement has both momentum and inertia.

Insulating Material. Asbestos, lava, and mica

are severally used for the insulation of spark plugs and sparking devices.

Vulcanized fiber or hard rubber or even hard wood are used for the bases of switches, connection boards, etc.

India rubber, or gutta-percha form the basis of the insulated covering of wires used for electrical purposes. The coils of small magnets and the cores of induction coils are usually wound with cotton covered wire, or in some instances the fine wire is silk covered, as in the case of secondary or jump-spark coils.

Instructions for Starting and Stopping. The regular order for starting an automobile engine is given in the following paragraphs. This order should be followed every time the engine is started, for this is the best way to avoid forgetting things; in fact, the beginner will do well to memorize these instructions.

1. Open the main gasoline valve at the tank. If the tank is hung low, and the gasoline is lifted to the carbureter by air pressure, ascertain—by priming the carbureter if necessary—that the tank has the required pressure, and pump air into it by hand, if necessary. A hand pump for this purpose is mounted on the dash, usually at the left end. Sometimes the gasoline passes through a small auxiliary tank on the dash, and this tank holds gasoline enough to supply the carbureter by gravity until pressure from the exhaust gases can be raised in the main tank.

2. Retard the spark as far as possible. This is of the first importance, as the attempt to start with the spark advanced may result in a broken arm. It is an excellent rule never to turn the starting crank, even when it is thought that no explosion can occur, without first seeing to it that the spark lever is retarded.

3. Set the throttle about one-quarter open.

4. Close the switch and insert the safety plug, if one is used.

5. Turn on the oil feed. It is assumed that any oiling and filling of oil cups done by hand has already been attended to.

6. Open the compression relief cocks, if there are any.

7. Prime the carbureter, by depressing the float or otherwise, according to its construction. If the motor has been stopped for not more than an hour or two, or sometimes longer, this is not necessary. If the tank has pressure feed, and the carbureter has been primed to test the pressure (see 1), it does not need to be primed again.

8. Engage the starting crank, and turn it over until the resistance due to the compression stroke is felt. If the starting crank is not now on its up stroke, move it backwards a quarter or half turn until it is, and reengage the ratchet at this new point. Never push the crank over the compression stroke. Even if the switch is open, a hot motor may start from pre-ignition, and a "back kick" may result in a broken arm.

9. Pull the starting crank upwards smartly against the compression. The motor may start. If it does not, turn the starting crank until the next compression stroke comes, and pull it upwards smartly as before.

If the carbureter has not been primed too much or too little, the motor should start unless the gasoline is too cold to vaporize. If it does not start with the second or third trial, prime the carbureter again and repeat the operation. If the motor still refuses to start, something may have been negleced or forgotten. It may be that the gasoline is not turned on, that there is no gasoline in the tank, or that it is stale or heavy, that the switch plug is not in place, that the battery is not strong enough, or that the method of priming the carbureter has given too light or too weak a mixture. The method of priming is something that will depend on the individual carbureter, and can only be learned by experience.

The procedure for stopping an automobile engine is to partly close the throttle so that the motor will run slowly and then open the switch; if the stop is permanent, take out the safety plug, shut off the oil feed, and shut off the gasoline at the tank. If the car has been run some distance it is well to squirt a small amount of kerosene through the compression relief cocks to loosen any carbon deposit that may have gathered around the piston rings.

Jacket—Water. Water-jackets that are cast

with the cylinder have the disadvantage that they cannot readily be cleaned when scale-deposits accumulate in them. Hence, the water-jackets for some small engines are made of sheet metal, as shown in Fig. 183. The water-jacket, shown at a, surrounding the cylinder b, is made of heavy sheet copper held in place, without gaskets, by means of the bolts c at one end and the right-and-left nipple d at the other

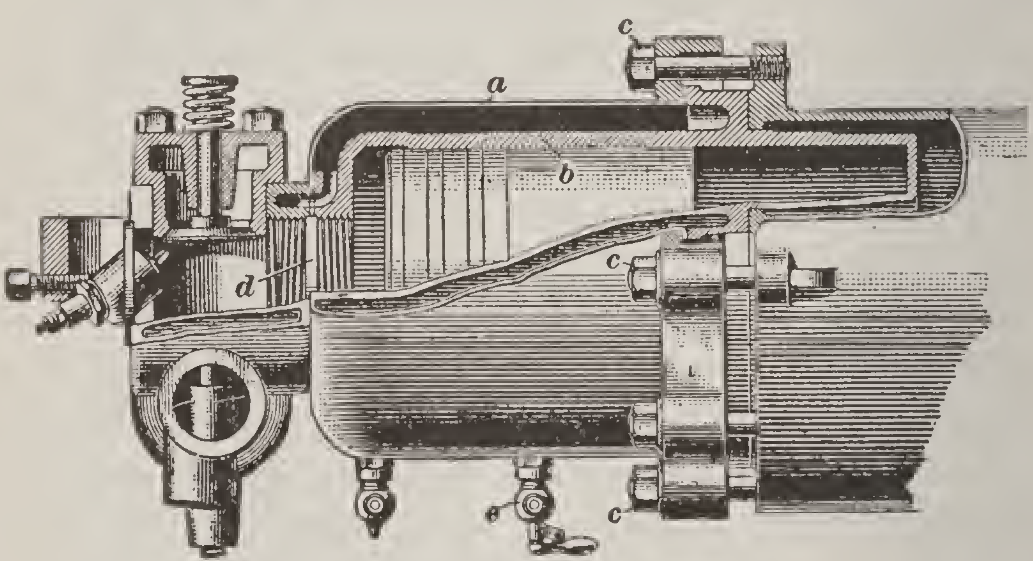


Fig. 183

end. A compression relief cock e, operated by means of a hand wheel on a rod extending outwards from the cock to a point outside the frame, is provided for reducing the compression pressure to facilitate starting. The water-jacket may be drained through a drain cock f screwed into a boss brazed to the outside of the jacket. Water-jackets of this type can be removed from the cylinder when it becomes necessary to clean them or when repairs to the

cylinder make it desirable. The cylinder shown in Fig. 183 is of the automobile type.

The thickness of the water-jacket space around the cylinder of an explosive motor should not be less than one-eighth of the bore of the cylinder, while the water space surrounding the head combustion chamber of the cylinder should not be less than one-sixth of the cylinder bore.

Bosses for pipe connections to the water-jacket outlet should always be placed at the highest point of the jacket, so as to prevent an air space being formed above the outlet of the jacket. Steam will be formed in this space, and with a gravity or thermal-siphon system is liable to blow, or force the water out of the cylinder jacket.

To obtain the greatest degree of fuel economy and motor efficiency the jacket water should be always of a temperature slightly under the boiling point of water. A cool water-jacket is a sign of an inefficient motor.

Water-jacket, Leaks in. A leak in the water-jacket of the cylinder of a gasoline motor may be due to one of two causes: Either to spongy places in the metal of the jacket from imperfect foundry work, or to cracks in the jacket from allowing the water to stay in the cylinder jacket during extremely cold weather, and the car not in use. The spongy place or crack may be repaired by using one of the two following solutions: Remove the cylinder from

the motor and first wash out the inside of the jacket with a 20 per cent solution of sulphuric acid and water, taking care, however, not to let any of the solution get on any of the finished parts of the cylinder. For a spongy place in the jacket use a saturated solution of sal-ammoniac, and place the cylinder in such a position that the spongy place is underneath; allow to stand in this position for at least two or three days. Then empty out the solution and leave the cylinder standing for two or three days more, until the leak has thoroughly rusted. For a cracked water-jacket, keep the water-jacket full of a saturated solution of sulphate of copper (blue vitriol) for at least four days. The crack is filled up by what is practically an electro-chemical deposit of pure metallic copper.

Joint—Universal. The elementary form of a universal-joint or flexible coupling consists of a spiral spring. Such a form of universal-joint is sometimes used to drive a rotary pump, or a small generator on a car. The rear wheels or axle of a car are sometimes driven by means of a longitudinal shaft with a quarter-turn drive on a counter shaft, or a bevel gear drive attached to the differential gear of the rear axle. In such cases some form of universal-joint is necessary to allow the rear wheels and axle to accommodate themselves to the inequalities of the road surface. Three forms of universal-joints are shown in Figure 184. The upper view in the drawings shows the form most generally

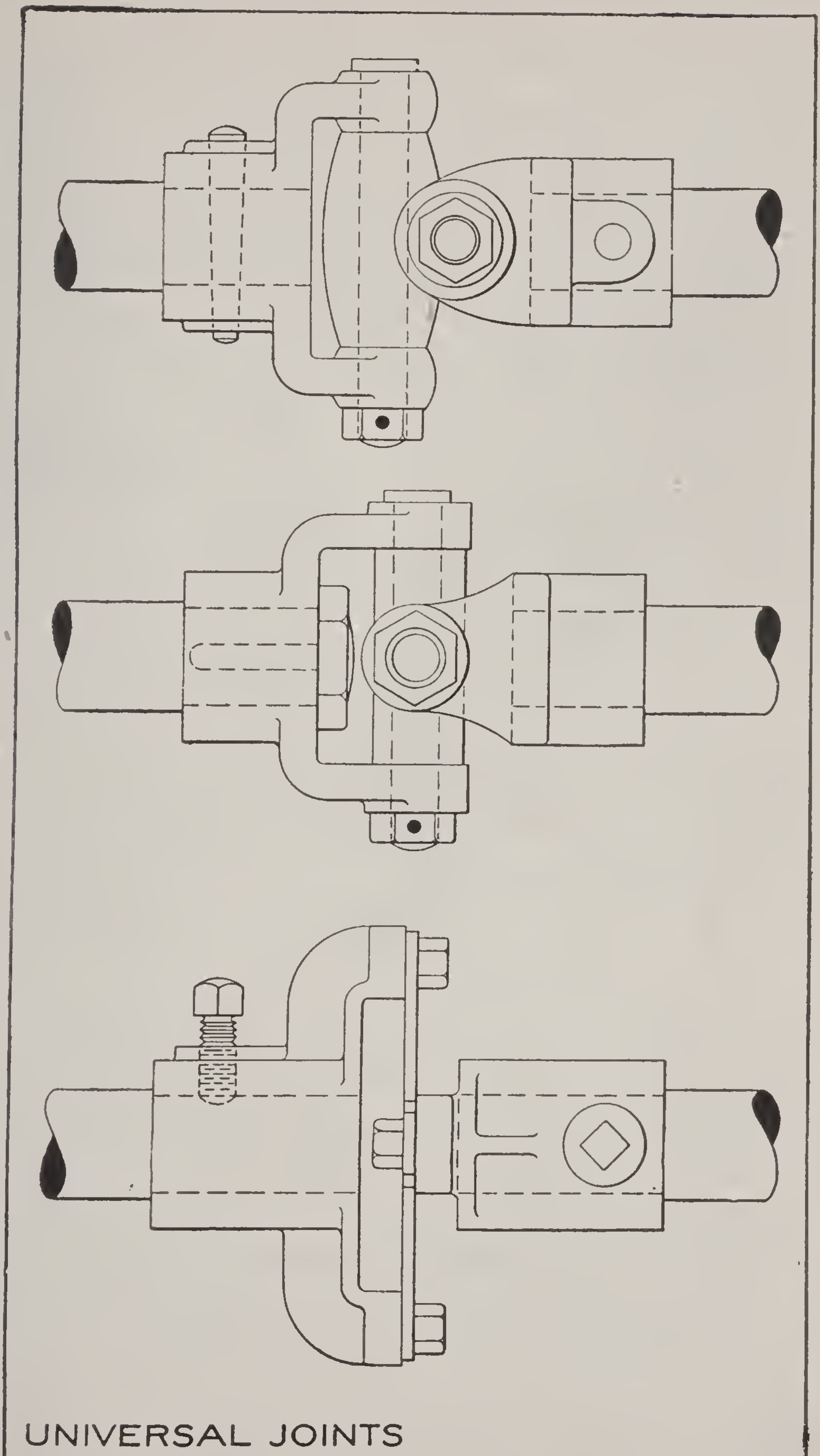


Fig. 184

used on motor-cars, for the purposes just described. The one shown in the center view will allow a greater amount of angular distortion than the form shown in the upper view, but is of a more expensive construction. Where only a slight amount of angular distortion is needed, the construction shown in the lower figure in the drawing is very suitable, the two jaws or

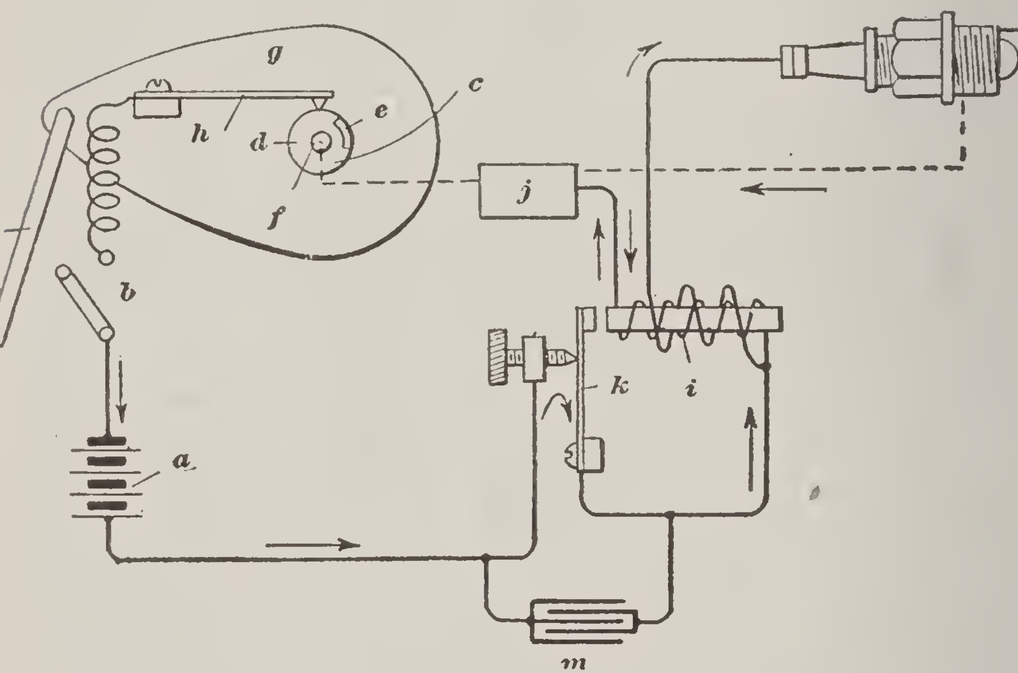


Fig. 185

knuckles of the joint being flexibly attached by means of a plate of spring steel in the form of a cross.

Jump Spark Ignition. In the diagram, Fig. 185, are shown the essential elements of a jump-spark system of ignition. Here a is the battery, b is a switch for opening the primary circuit when it is not in use, and c is a revolving timer turning at one-half the speed of the

crank-shaft, if the engine is of the four-cycle type. The timer in the elementary apparatus shown consists of an insulating ring d mounted on the shaft and having dovetailed into it a copper or brass segment e, in electrical connection, by a screw or otherwise, with the shaft f. A plate g is mounted loosely on the shaft, so that it does not turn with it, but may be rocked about it through a suitable arc, say 45°.

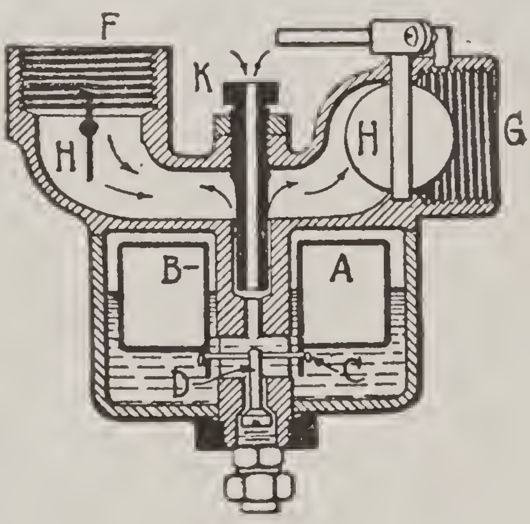


Fig. 186
Kalamazoo Carburetor

Mounted on this plate, and insulated from it, is a brush h, that bears against the insulating ring and makes contact with the metal segment at each revolution of the latter. The primary winding of the spark coil is represented by i, and j is the ground on the engine. A trembler, k, similar to an electric buzzer, is provided so that the current may be rapidly interrupted.

A full description of the construction and

operation of the jump spark coil is given in the section on electric ignition.

Kalamazoo Carbureter. Fig. 186 shows a sectional view of this carbureter, the operation of which is as follows:

First, the concentric float A has a brass tube B inserted in its hub part, which guides it on the central part of the float chamber, and through the top of the float valve D for controlling the entrance of gasoline into the float chamber. Second, the connecting pin operates in a slotted portion of the float chamber hub. Air enters by the opening F, and mixture escapes through the passage G, both controlled by butterfly valve H, one for regulating the supply of air, so that on cold mornings the air supply is limited, and a richer mixture obtained because of the greater pull on the gasoline, and the more of it that is drawn. Third, the needle valve K is novel in that it is termed an air lift system. The valve has its lower end within a well part of the nozzle, the well being on a level with the gasoline level in the float chamber. The valve K is hollow for admitting air from the outside, so that with a heavy motor pull the air is drawn through the valve, as indicated by the arrows, and rises through the gasoline in the well, lifting it with it and carrying it into the mixing chamber. The valve is adjustable, and can be set to give a suitable mixture for the varying motor speeds.

Kerosene as a Fuel. Kerosene has been used

as an explosive power, and crude petroleum is gaining favor as an efficient liquid fuel. With a specific gravity varying from 0.78 to 0.82, and a vapor flashing point at 120 to 125 degrees Fahr., kerosene ignites at 135 degrees Fahr., and boils at 400 degrees Fahr. Its vapor is five times heavier than air, and requires 76 cubic feet of air to one cubic foot of vapor for

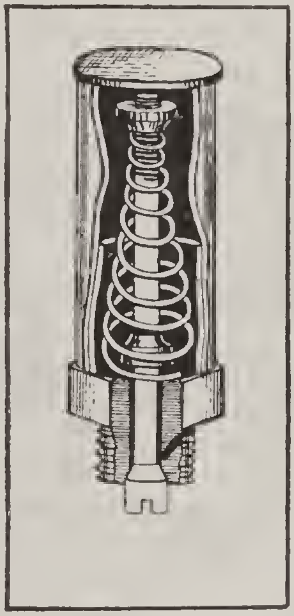


Fig. 187

its combustion, giving 22,000 heat units per pound, or 4,000 more than gasoline.

KEROSENE AS A CLEANSING AGENT. Kerosene injected into a motor cylinder and allowed to remain over night will remove all deposit from the piston head. It should then be blown out through the relief-cock or the exhaust-valve.

Kerosene is also used to remove the gummy residue left on the piston and the cylinder wall by the lubricating oil. When injected into the

cylinder in the manner above described, it facilitates the starting of the motor, if it has been standing idle for any length of time.

Figure 187 shows a form of kerosene cup which may be permanently attached to the motor. After removing the cap, the cup is filled and the kerosene admitted to the motor cylinder by depressing the valve-stem.

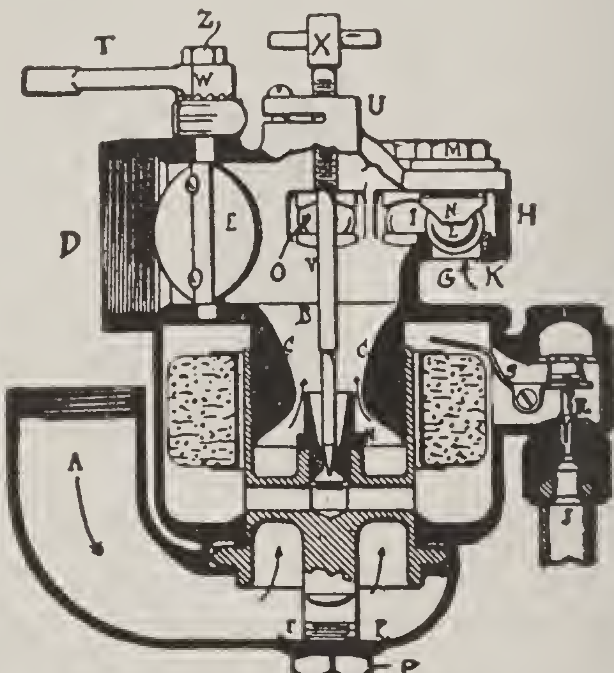


Fig. 188
Kingston Carburetor

Key—Inlet or Exhaust-Valve. Trouble from a broken inlet-valve stem, or key is more likely to occur with automatic valves than with those mechanically operated. The result, if the valve opens downwards, is to let it stay open all the time, causing that cylinder to cease work, while the sparks from the plug ignite the mixture in the intake pipe, and cause explosions there and

in the carbureter. If the valve, whether automatic or mechanically operated, opens upwards, it will clatter on its seat and permit much of the mixture to be expelled during the first part of the compression stroke.

Valve-stem keys should be made of annealed tool steel, and should not be made too close a fit in the valve-stem slot, because they are likely to bend slightly in use. Ordinarily it is cheaper to buy these keys of the maker of the car than to make them specially. One or two spare keys should always be carried.

Kingston Carbureter. The Kingston carbureter, Fig. 188, uses a ball type of auxiliary air valve instead of the employment of spring control dashpot, diaphragm or auxiliary air valve. The main air intake A communicates with the vertical mixing chamber B, in which the sides C are beveled outward, giving a center tube effect, so that the air current converges above the nozzle N, as indicated by the arrows. D marks the exit to the motor controlled by the butterfly throttle E. Auxiliary air enters through five circular openings G, arranged in a semi-circle in the floor of an extension H of the mixing chamber. Each of these five openings consists of a bushing K threaded into the opening in the extension H, and having its top beveled to receive a five-eighths inch bell metal bronze ball L, which is retained in position by a threaded bushing M, fitting in the top of the extension H. It has a pair of downward project-

ing hooks N for preventing the ball getting out of position, but not interfering with the ball rising vertically when forced to do so by the pull of the motor, at which time additional air is admitted. Two others of the five auxiliary entrances are shown at I and O, all of the five containing balls of the same size and weight. The air entering through the openings guarded by these balls has an unrestricted passage into the mixing chamber and thence to the motor. Any ball is easily moved by unthreading the cap M, after which the ball can be lifted out.

The gasoline enters the carbureter from the gasoline tank by way of the connection J, which is guarded by the needle valve R. operated through the lever S. pivoted in the side of the casting and with its long arm bearing on the top of the cork float. The float is fitted with a metal bushing. Complete control of the nozzle N is through the needle valve V, which. at the top of the carbureter, has a T-piece X, by which it can be raised or lowered, thereby regulating the flow of gasoline. A feature of the throttle connection T is the serrated lower face of its hub W. so that by loosening a lock nut Z, the handle T may be turned in any direction most convenient. The air intake A consists of an L-shaped piece secured to the carbureter casting by a nut P. and in the base of this is a circle of openings F where currents of air can enter, the object of these openings being that by priming the carbureter, and

overflowing the open mouth of nozzle N the gasoline falls to the vicinity of the holes F, and the air entering through these openings will facilitate the breaking up of the gasoline, and thereby assist the starting of the motor.

Knocking—Locating Cause of. Tracing a knock is sometimes a puzzling job. It may be in one of the main bearings of the engine, in the camshaft bearings, in a loose valve lifter, in a loose camshaft gear key, in a loose pump or magneto drive coupling, an unsuspected loose bolt between two parts supposed to be fast, or in any of a dozen, or score of other unsuspected places. A valuable aid in locating a mysterious knock is a flexible speaking tube such as is used with phonographs. One end of such a tube can be held to the ear and the other moved about from point to point until the exact spot is found where the noise is loudest. Another aid is a light bar of iron, one end of which is pressed against the part where the knock is suspected and the other touched to the forehead or the teeth, when the sound is clearly transmitted.

Knocking or pounding is an inevitable warning that something is wrong with a motor. It may be due to any of the following causes:

Premature ignition: The sound produced by premature ignition may be described as a deep, heavy pound.

Using a poor grade of lubricating oil will cause premature ignition. The carbon from the

oil will deposit on the head of the piston in cakes and lumps, and will not only increase the compression, but will get hot after running a short time and will ignite the charge too early, and thereby produce the same effect as advancing the spark too much. If this is the cause the pounding will cease as soon as the carbon deposit is removed from the combustion chamber.

Badly worn or broken piston-rings.

Improper valve seating.

A badly worn piston.

Piston striking some projecting point in the combustion chamber.

A loose wrist-pin in the piston.

A loose journal-box cap or lock-nut.

A broken spoke or web in the flywheel.

Flywheel loose on its shaft.

If the spark plug be placed so as to be exactly in the center of the combustion space, an objectionable knock occurs, which has never been fully explained. In some motors it renders a particular position of the spark control lever unusable; this form of knock disappears either on making a slight advance or retardation of the ignition.

Explosions occurring during the exhaust or admission stroke. This is almost always due to a previous misfire, and it is prevented by stopping the misfires.

If the ignition is so timed that the gases reach their full explosion pressure during the compression stroke, that is, if the spark be unduly

advanced when the motor is not running at a high speed, an ugly knock occurs, and great pressure is developed on the crank-pin bearing, wrist-pin, and connecting rod. The result may be the bending or distorting of the connecting rod.

The crank-pin may not be at right angles to the connecting rod. This cause of knock is often hard to find.

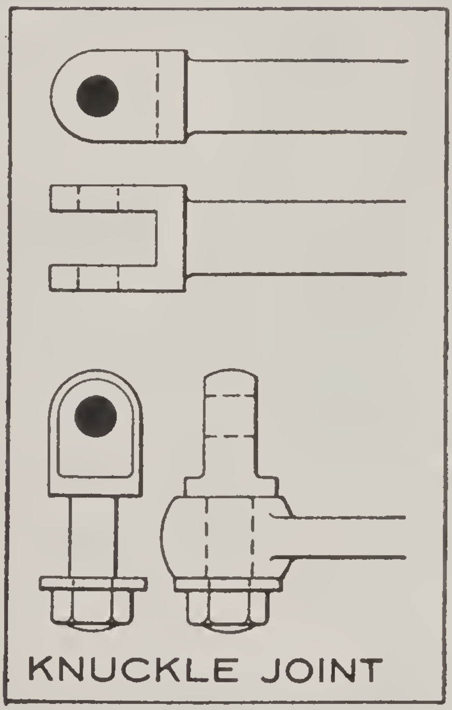


Fig. 189

The chain may perhaps be loose. This produces a blow if the chain should jump one of the sprocket teeth. The noise is not usually called a knock because it does not recur at uniform intervals. It is dangerous to run with a loose chain, as breakage might precipitate a car down a hill backwards.

The bearings at either end of the connecting

rod may be loose. A knock during the explosion stroke, and also at each reversal of the direction of the piston.

If the crank shaft is not perfectly at right angles to the connecting rod, the crank shaft and flywheel will travel sideways so as to strike the crank shaft bearings on one side or the other.

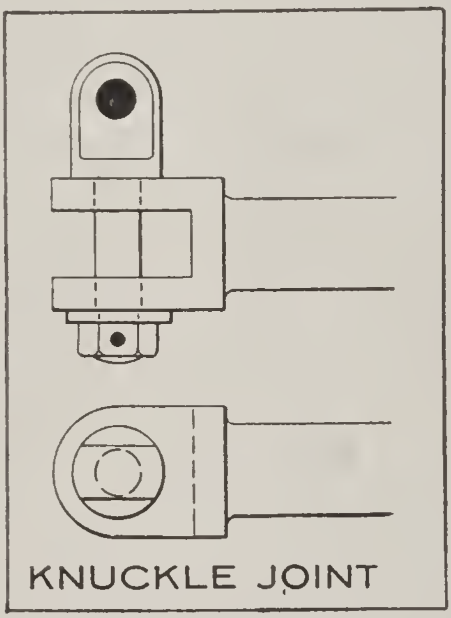


Fig. 190

Knuckle Joints. Swivel or knuckle-joints for connecting the steering arm of the wheel, or lever steering mechanism to the arms on the knuckle-joints of the steering wheels are of various forms. Figures 189 and 190 show knuckle-joints which may be used for the above purpose. They are of simple construction and practically inexpensive to make. They may be used with any standard drop-forged jaw-ends.

Komet High Tension Magneto. The Komet

high-tension magneto, Fig. 191, combines the primary and secondary windings on the armature, so that no coil is required. The field consists of three permanent magnets secured to a bronze base. The make-and-break device is

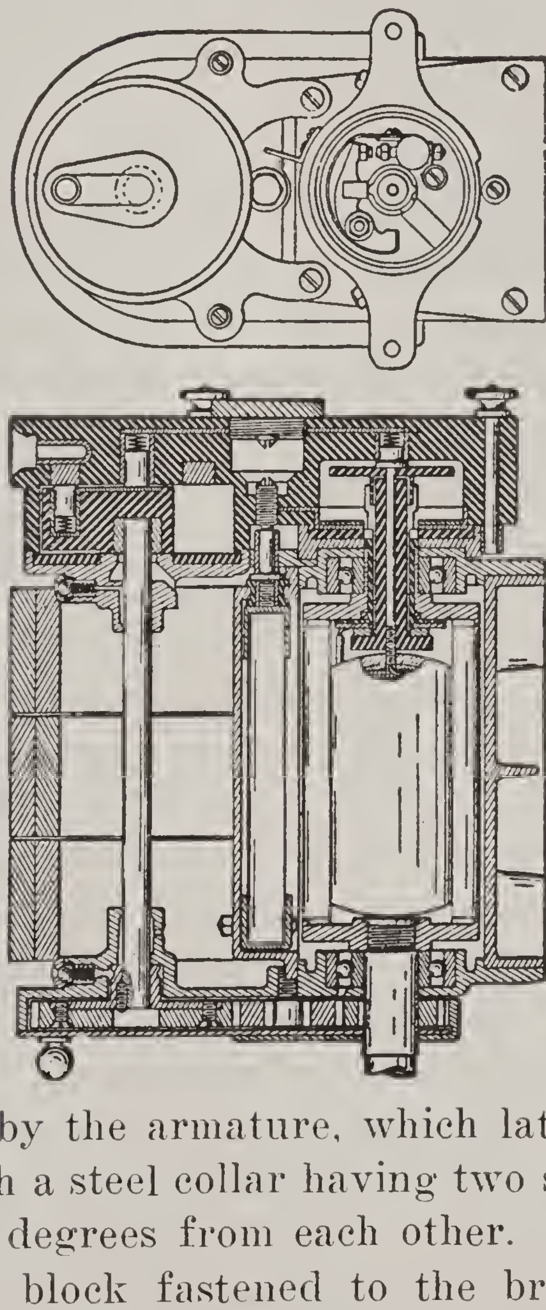


Fig. 191
Komet High-Tension Magneto

operated by the armature, which latter is provided with a steel collar having two spurs upon it, at 180 degrees from each other. These rub against a block fastened to the breaker arm and separate the platinum point on this arm from a stationary platinum button. A curved

spring holds the arm in contact when not actuated by the spurred collar. The distributer is fitted above the make-and-break, and consists of a circular vulcanite block having a brass arm and spring pressed carbon brush, which makes contact with four or six brass blocks in the vulcanite casing enclosing the distribution mechanism.

Krebs Carbureter. In the Krebs style of carbureter, a constant proportion of gasoline and air is maintained by means of suitable sections of air and gasoline outlets. The openings are so arranged that a proper mixture is maintained at minimum suctions, after which gradually increasing quantities of supplementary air are admitted.

A number of attempts have been made to improve upon the Krebs principle by variously shaping the supplementary air openings, or the spring on the supplementary air valves, so as to insure complete compensation for the increase in richness of the mixture formed in the spray chamber with increasing suction, by the addition of the correct amount of supplementary air at all suctions. The mixture formed in an ordinary spray carbureter becomes richer as the suction increases. At first the only means provided to correct this defect was a hand-regulated air valve; but since the advent of the Krebs carbureter, practically all new carbureters brought out have some arrangement for automatically keeping the mixture constant, re-

gardless of variations in suction. In general the means provided are close copies of the Krebs supplementary air valve, though in some instances this valve, instead of being actuated by the suction, is operated either hydraulically by means of a diaphragm in a chamber communicating with the water cooling system, or mechanically by direct connection with the throttle valve.

Krouse Carbureter. The Krouse carbureter has eleven spraying nozzles, which can be brought into use, one at a time until all are emitting gasoline. This carbureter resembles a drum placed on end. The drum is nearly all float chamber, with a concentric air chamber surrounding the float chamber. The top of the float chamber is fitted with eleven standpipes, the bottoms of which conduct the gasoline into the float chamber. These eleven nozzles form a semi-circle, and immediately above them is a metal semi-circle which can be revolved so as to cover any number, or all of the nozzles, thus shutting them off entirely. Around each nozzle is a small air vent, to allow the air to rise past the mouth of the nozzle, and mix with the gasoline. There are no springs, and the only moving part is the throttle, which is the metal semi-circle before mentioned, and which effectually shuts off gasoline and air, one nozzle at a time.

Lamps. It goes without saying that the burners should be kept clear, wires being passed

through the gas apertures and the air apertures at intervals. The burners should be unscrewed occasionally and blown through, and the interior of the burner body scraped clean of deposit. Outside of keeping the lenses and glasses bright, and polishing the exterior of the lamp, there need be no other attention paid except to keep all joints and the bracket screws or nuts tight.

By far the best and handiest thing to clean the lens mirrors is a mixture of equal parts alcohol and water. Denatured alcohol answers the purpose perfectly well. Pure alcohol evaporates so quickly that it leaves the greasy film pretty much as it was, whereas a 50 per cent solution evaporates more slowly and gives time to wipe the glass clean. It would be an excellent idea for every garage to keep a bottle of this solution and some clean rags always on hand. While on the subject of lamps it is worth mentioning that all gas tubing from a generator should slope either downward, or away from the generator, and there should be provision for draining it at its lowest point, since there is a gradual condensation of water in the piping which, if it collects in pockets, results in objectionable flickering.

The Condenser. When used at all, the condenser or its substitute is put off in some position where it becomes caked with mud and is almost forgotten until it is full and the lamps begin to flicker. Then the mud is cleaned from

it and it is drained out. It should be placed so that it is close to the lamps, where it will catch all of the condensation from the gas going to the burners, and in addition any water that may enter the burners due to washing of the car. It should be emptied from time to time, say once or even twice a month, when the lamps are in regular use. The majority of troubles with acetylene lamps are due to lack of a condenser, and to the use of too small metal tubing.

Leakage—of Current. Sufficient leakage of current to make trouble—but not enough to be observed without testing with a magneto—may be due to moisture in the mica insulation of the insulated electrode, or to a bridge of carbon. When it is suspected that the trouble is due to either of these causes, it is a good plan to dry out the insulation thoroughly and clean the lower end with a brush or piece of waste and a little gasoline.

These troubles are more liable to occur when the batteries have become weak from use, or so far exhausted that they will not give sufficient current for ignition.

Leakage of Water or Gasoline. This is usually due to carelessness, and indicates a slovenly operator. The loss of water, if small, may be left till the run is completed. A leakage of gasoline is far too dangerous to leave alone under any circumstances. A common cause is a minute hole in the float of the carbureter, causing it to flood. The hole can be found by

putting the float into boiling water and watching for bubbles. Leaky joints in gasoline or water pipes may be made tight by means of coarse linen or canvas, covered with a paste of litharge and glycerine. This should be again covered with a bandage of adhesive or sticky tape, such as is used for electrical purposes.

Learning to Operate a Car. Learn to distinguish normal sound of the motor and its valves, from the following:

Knocking which may be due to a worn or loose bearing.

The absence of explosion in one of the cylinders.

A hissing noise due to leakage of the compression.

A sharp spitting due to leakage during the explosion stroke.

Any pounding of the admission-valve on its seat.

Any racing of the motor.

The sound of an unoiled or dry bearing.

The rattle of a part becoming loose.

Owing to the value of the indications from the above, it is important that no oil-cans, spanners, or other tools, should be left loose in the car.

A little practice will enable the operator to distinguish the beat of the motor, and the vibration due to the springs, from the jumping, due to road surface, so as to note at once:

A broken gear tooth.

A loose chain.

A deflated or punctured tire.

A broken spring.

Ineffectual explosions due to poor compression.

Backlash in steering gear.

Lehman Distributer. Fig. 192 shows the Lehman distributer for four and six-cylinder

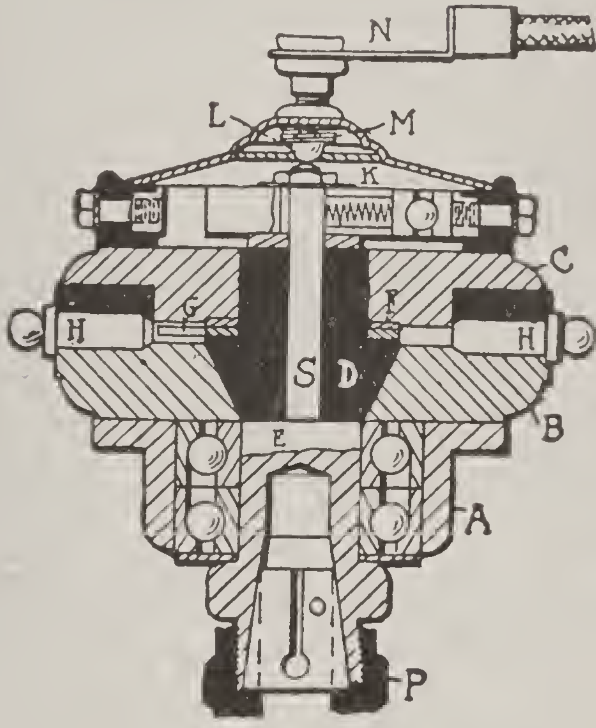


Fig. 192
Lehmann Distributer

cars. The body A has bolted to it a hard rubber insulation B, which is grooved to receive the similar insulation C, and coned to take the vulcanite cone part D, which revolves with the shaft S. This shaft D is a continuation of shaft E, but of smaller diameter, the larger diameter part being supported on a double race of ball bearings. Secured to the vulcanite cone F is a

distributing disc G, and attached to the under surface of C is a collecting disc. The rotating disc G wipes the ends of the terminals H. The timer portion K is of regular construction as used in the Lehman timer. For the purpose of taking off the ground wire a small ball L is held against shaft S, through spring M, and a spring connection N couples for the wire. In attaching this distributer to its shaft the usual method

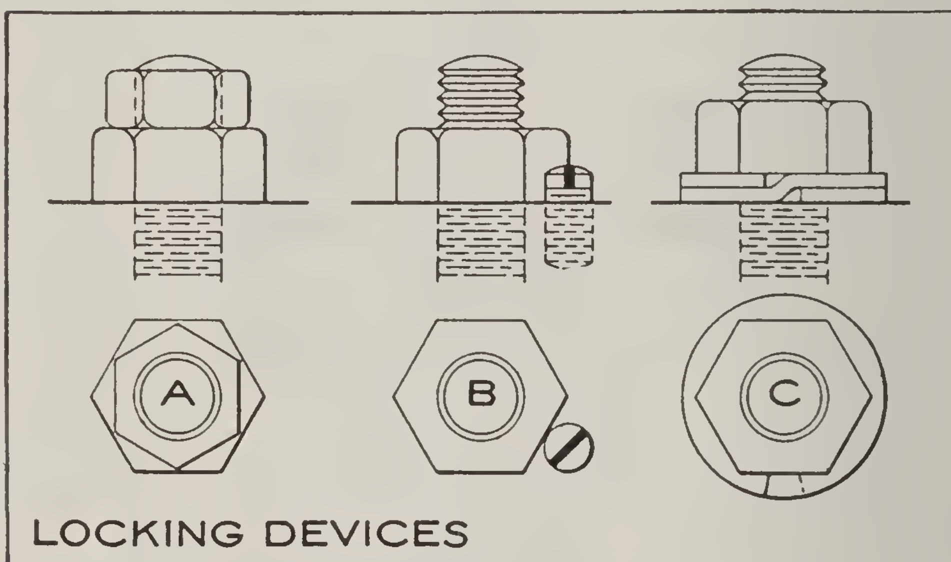


Fig. 193

of keying, or pinning is dispensed with, and recourse is had to a split cone O, which fits within the tapered bored end of shaft E. A jam nut P serves to anchor the split cone O to the drive shaft.

Locking Devices, for Bolts and Nuts. All bolts and nuts upon a motor car which are not provided with locking devices should be inspected at frequent intervals and tightened if necessary. The vibration and jars to which a

motor car is subject have an astonishing way of loosening bolts and nuts. Figures 193 and 194 illustrate six different methods of preventing bolts and nuts from becoming loose.

A—A lock-nut, which should be a size smaller than the nut proper, as shown in the drawing.

B—A headless set screw, tapped into the part which receives the bolt.

C—A spring washer under the nut.

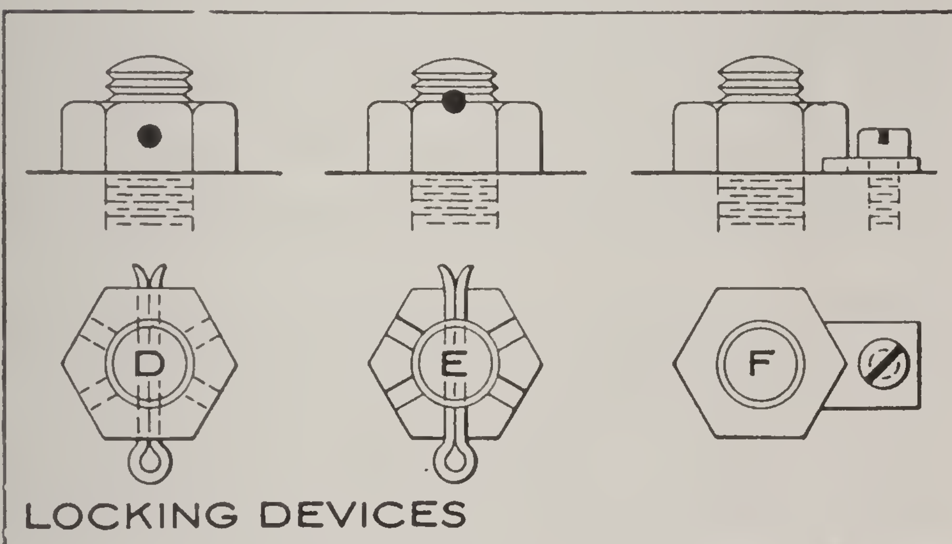


Fig. 194

D—A split pin through both bolt and nut.

E—A split pin through the bolt only, but fitting in half-round grooves in the nut.

F—A nut-lock with holding down screw.

Loose Connections. These occur in the most peculiar places. Sometimes a platinum tip gets free from its carrying screw, sometimes a lead lug breaks inside a storage battery cell. Sometimes a disconnection occurs by breakage of a copper wire inside its unbroken cover.

Lubrication. To ensure easy running, and reduce the element of friction to a minimum it is absolutely necessary that all surfaces rubbing together should be supplied with oil or lubricating grease, but it is also a fact, not so well understood, that different kinds of lubricant are necessary to the different parts or mechanisms of a motor car.

As the cylinder of an explosive motor operates under a far higher temperature than is possible in a steam engine, consequently the oil intended for use in the motor cylinders must be of such quality that the point at which it will burn or carbonize from heat is as high as possible.

While a number of animal and vegetable oils have a flashing point, and yield a fire test sufficiently high to come within the above requirements, they all contain acids or other substances which have a harmful effect on the metal surfaces it is intended to lubricate.

LUBRICATING OILS. The qualities essential in a lubricating oil for use in motor cylinders include a flashing point of not less than 500 degrees Fahrenheit, and fire test of at least 600 degrees, together with a specific gravity of 25.8.

At 350 to 400 degrees Fahrenheit, lubricating oils are as fluid as kerosene, therefore the adjustment of the feed should be made when the lubricator and its contents are at their normal heat, which depends on its location in the car. Steam engine oils are unsuitable for the dry

heat of motor cylinders in which they are decomposed whilst the tar is deposited.

All oils will carbonize at 500 to 600 degrees Fahrenheit, but graphite is not affected by over 2,000 degrees Fahrenheit, which is the approximate temperature of the burning gases in an explosive motor. The cylinder of these motors may attain an average temperature of 300 to 400 degrees Fahrenheit. So that graphite would be very useful if it could be introduced into the motor cylinder without danger of clogging the valves, and could be fed uniformly. These difficulties have not yet been overcome. Graphite is chiefly useful for plain-bearings and chains.

The film of oil between a shaft and its bearing is under a pressure corresponding to the load on the bearing, and is drawn in against that pressure by the shaft. It might not be thought possible that the velocity of the shaft and the adhesion of the oil to the shaft could produce a sufficient pressure to support a heavy load, but the fact may be verified by drilling a hole in the bearing and attaching a pressure gauge.

Roller and ball-bearings provide spaces, in which, if the oil used contains any element of an oxidizing or gumming nature, a deposit or an adhesive film forms upon the sides of the chamber, the rollers or balls, and the axle. This deposit will add to the friction, hence it is the

more important to use a good oil, or a petroleum jelly in such bearings.

Air-cooled motors, being hotter than water-cooled, must have a different lubricant, or one capable of withstanding higher temperatures.

The effect upon animal or vegetable oils of such heat would be to partially decompose the oils into stearic acids and oleic acid and the conversion of these into pitch. Such oils are therefore inadmissible for air-cooled motor use.

Mineral oils are not so readily decomposed by heat, but at their boiling points they are converted into gas, and any oil, the boiling point of which is in the neighborhood of the working temperature of the motor cylinder, is useless, as its body is too greatly reduced to leave an effective working film of oil between the cylinder and the motor piston.

The essentials for the proper lubrication of air-cooled motors are:

That the oil should not decompose.

That it should not volatilize, as this will result in carbon deposits.

That its viscosity should be equal to that of a good steam engine oil at similar temperatures.

That it should be fluid enough to permit of its easy introduction into the cylinder.

That it will have no corrosive effect on the cylinders and no tendency to gum.

That it will not oxidize with exposure to air and light.

LUBRICATING DEVICES. Some makers of verti-

cal cylinder motors use the splash system, whereby oil fed by gravity from a tank above the level of the crank-case flows into the crank-case, whence it is splashed over the piston and the wrist and crank-shaft bearings. The large end of the connecting rod, which works in the crank-case, is made to dip or splash into a bath of oil. This lubricates the crank-pin. The splashing is invariably utilized to lubricate the cylinder by wetting the bottom of the piston

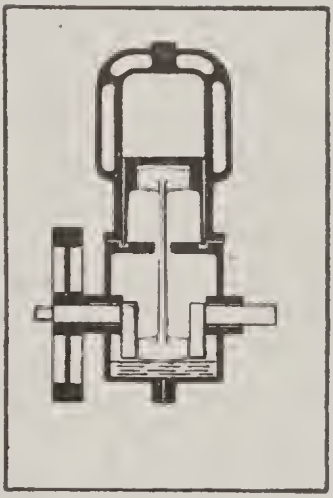


Fig. 195

and splashing into the cylinder. A little ring is sometimes made in the crank-case, into which the oil collects and into which also the end of the piston dips. The oil usually requires changing every 100 miles on small motors, or every 75 miles on large.

Figure 195 shows a vertical cylinder motor using splash lubrication.

With the use of high-speed gasoline motors, it has been found necessary to use a forced circulation of the oil in order to completely lubri-

cate the interior of the cylinder. The usual method with high-powered motors is to employ a belt-driven pump to force the oil through adjustable conduits to the various moving parts. Such pumps, operating in ratio to the speed of the motor, supply lubricant more rapidly as the motor speed increases, and less as it decreases. Thus, a perfect supply is maintained, on the one hand, and flooding of the motor is prevented on the other.

Where horizontal cylinders are used, it is customary to use grease cups, and to control the feed by mechanical or spring pressure. Such devices are less suitable for vertical cylinder motors, which require oil in large quantities and exact adjustment in its flow. One very useful feature of oil pump lubrication is, that the flow of oil may be kept in proportion to the speed of the motor. This is a very necessary feature, as without it flooding is liable to result.

Lubricators. It should be ascertained from the maker of the car how many drops of oil per minute are necessary for the different mechanisms of the car, including the motor. The lubricators should then be set accordingly.

It should be remembered that in cold weather when the oil is thick a different adjustment of the lubricators will be necessary from that found suitable in warm weather. It is important that the lubrication should be regular, and good oil used, but not too much. Too much oil will foul the spark plugs, clog the valves, and

interfere with the quality of the explosive mixture. For this reason the lubricators should always be carefully closed when the car is stopped. If a mechanical lubricator is used, examine the mechanism sometimes, and do not trust entirely to the feed. If a pressure lubricator is used, see that the piston or cap is tight, for if not the pressure will stop the lubrication.

It sometimes happens that an oil pipe or oil

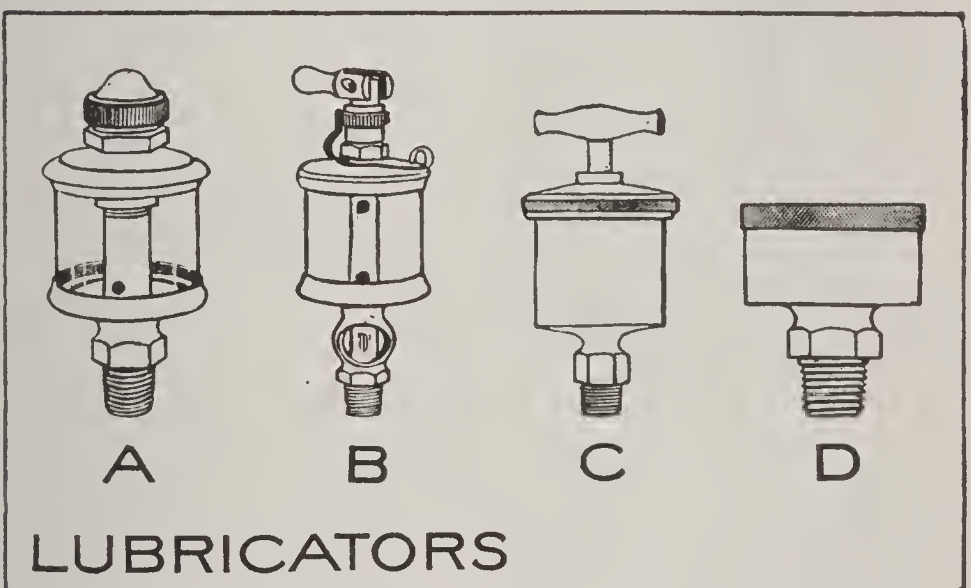


Fig. 196

hole is stopped up and needs cleaning, or perhaps the plug at the bottom of the crank chamber has come unscrewed and dropped out, losing all the oil. The proper amount of oil in the crank-case is about half a pint. An extra lubricator leading to the cylinders and crank-case should be fitted, so that extra oil can be fed by a hand pump, if there is any doubt about the motor getting enough.

Figure 196 shows four forms of lubricators for automobile use.

A—Plain, glass body oil cup, feeds only when shaft is running.

B—Sight feed, glass body oil cup, has an index-arm on top which indicates whether the oil feed is off or on.

C—Pressure feed, piston form of lubricator, for heavy bodied oil; the oil is forced into the

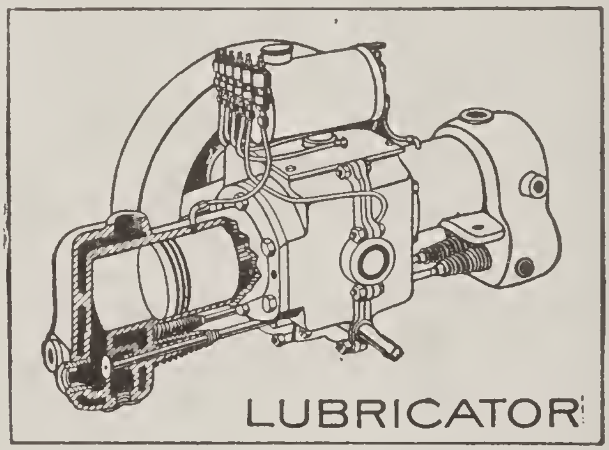


Fig. 197

bearings by means of a spring-actuated piston in the lubricator.

D—Plain grease cup, oil or grease forced into the bearing by screwing down the cap.

A form of pressure lubricator is illustrated in Figure 197, in which a slight pressure from the crank-case of the motor causes the oil to be forced through the pipes leading to the different parts of the motor. This form of pressure lubricator is only applicable to opposed cylinder motors with enclosed crank-case, as shown in the drawing, or to vertical two-cylinder mo-

tors with both pistons connected with one common crank-pin.

Force Feed Lubricators. Of all the oiling systems in use, the mechanical oiler, or force feed lubricator, has the largest application, and is generally used in connection with the splash system. The oiler is generally located under the bonnet, so that the oil in it will be of a more uniform temperature in both summer and winter, but several cars carry it upon the dash. When placed under the bonnet, oilers are usually located at the rear of the motor, but sometimes they may be found under the exhaust manifold, where a hotter and more even temperature may be maintained.

The method of driving mechanical oilers differs in the different cars In some cases they are gear driven, in others an eccentric drive is employed, and in still other cars the belt or chain drive is used, although the latter method is being rapidly discarded.

The number of feeds used varies on the different cars from two to fourteen, depending upon the number of cylinders and bearings used on the engine. In a six-cylinder car, it is usual to find four feeds going to the crankshaft bearings, six to the cylinders, three to the crankcase compartments, and one to the fan bearing.

When mechanical oilers are used for lubricating the motor, the crank-case is usually divided into partitions, most of them dividing it

into halves, one compartment for the two front cylinders and the other for the two rear cylinders. Sometimes three partitions, giving four compartments, are used. This arrangement gives one portion for each connecting rod.

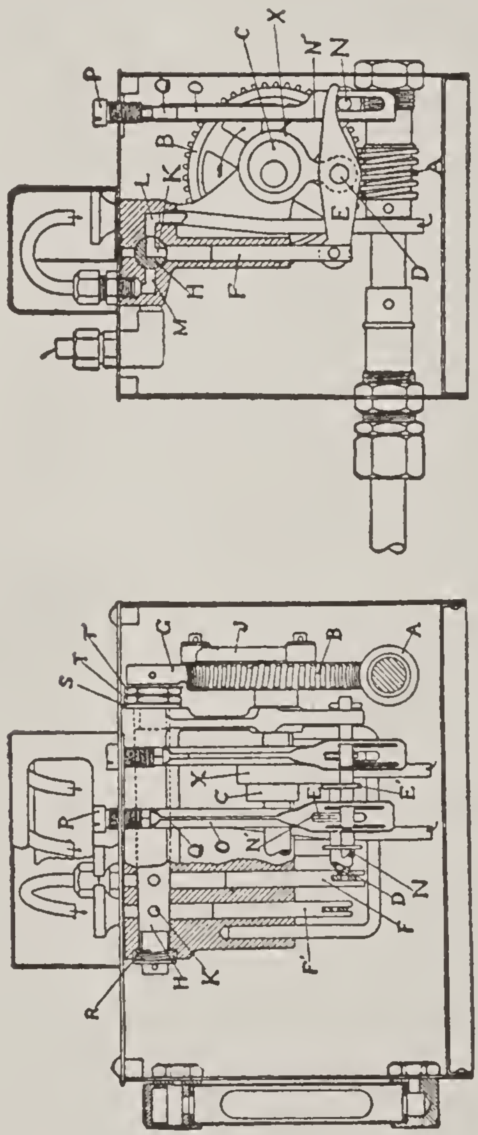


Fig. 198
Hancock Mechanical Oiler

When this construction is used, the center partition will be found higher than the other two.

A force feed lubricator usually consists of an oil tank through which passes a shaft, which has a slow, but constant motion through me-

chanical connection with the engine. This shaft successively operates by means of cams, or otherwise, a series of small piston pumps, usually submerged in the oil, each pump feeding an oil tube. The piston displacement of each pump may be adjusted independently by changing the length of stroke so that any amount of oil desired may be delivered. Each pump stroke corresponds with a definite number of engine strokes.

In some systems of force feed lubrication the oilers are made without valves, double plungers being used to force oil to the sight feeds, and drawing positively from the sight feed and forcing to the delivery points.

The Hancock lubricator, Fig. 198, is of this type, and action is as follows: Worm A drives worm gear B and the shaft to which it is attached. On this shaft are two eccentrics C which impart a reciprocating motion to rod D carrying rocker arms E, and E′. To one end of these arms are fastened pistons F, and F′. The crank G is secured to the taper shaft H, and through connecting rod J a rocking motion is transmitted. This taper shaft H is provided with holes K, which on the suction stroke register with the openings L, and L′, and the pistons, and on the forcing stroke with openings M, M, and the pistons. The arrows indicate the direction of flow of the oil to delivery points, the quantity being regulated by controlling the stroke of piston F through the lost

motion allowed between the stop rod L and regulating piece O. P is the regulating screw, provided with a projection Q. which fits firmly into the upper end of piece O, forming a positive locking device. Shaft H is equipped at one end with a spring R which holds it to its seat.

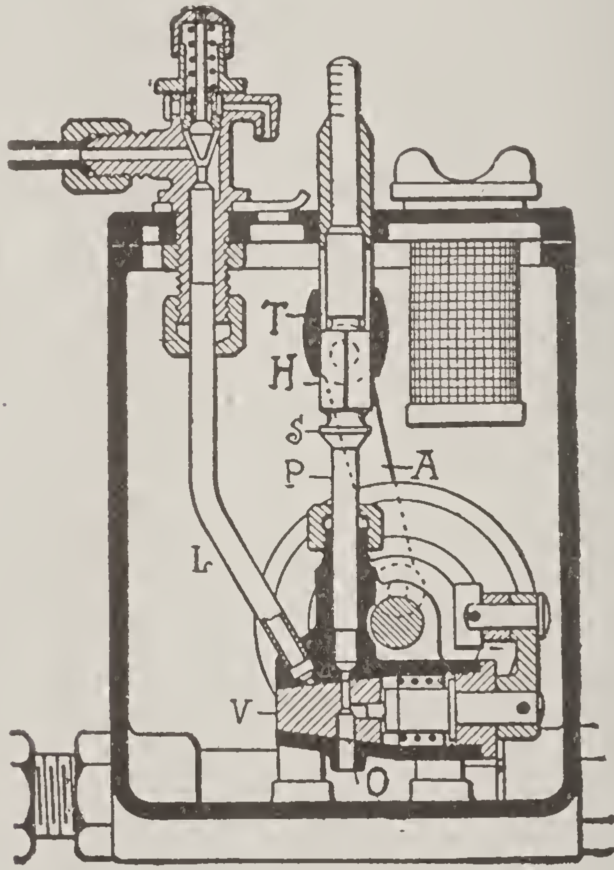


Fig. 199
Lavigne Oiler

At the other end, washer S and two lock-nuts T and T′ hold the shaft in its correct position. The shaft is thus allowed to run free in its gear, requiring but little power. Any number of feeds from one to sixteen may be used to work against pressure. In the Lavigne mechanical oiler, Fig. 199, the pumps are without check

valves, or springs of any kind. The plungers P, are raised and lowered by arms A attached to the drive shaft. On the up stroke a certain quantity of oil is drawn into each pump cylinder, and on the down stroke this quantity is discharged.

At the base of each plunger is an oscillating valve V, which, as illustrated, has the opening O ready for the up stroke, so that oil may be drawn from the reservoir into the plunger. Before the down stroke begins, the valve is oscillated by a cam device so that the entrance O is closed and the oil is directed through the lead L, which connects with the bearings. There is a time when the plunger L, is stationary at the top, and also at the bottom of the stroke, which is achieved by the cross head H, which raises and lowers the plunger. This cross head slides on the plunger until it contacts with a lower shoulder S and an upper one T. And during the period of no movement of the plunger the valve V is being oscillated to be ready to open the entrance O for intake stroke, and another passage for the expulsion stroke.

The Pierce-Arrow oiling system, Fig. 200, is partly positive, and partly gravity. The oil pump is positively driven from the engine, and pumps the oil from the crank chamber up into the reservoir located on the engine. Pipes lead from this reservoir to every crankshaft bearing, the flow to the bearings being by gravity under a head of twelve inches, which corre-

sponds to a pressure of about six ounces. The crankshaft bearings are drilled hollow, and in this way the crankpins and large ends of the connecting rods are lubricated. A gauge is usually placed on the dash to indicate the quantity of oil in the reservoir.

The Pierce system does not allow any oil to remain in the crankcase, the oil flying off the

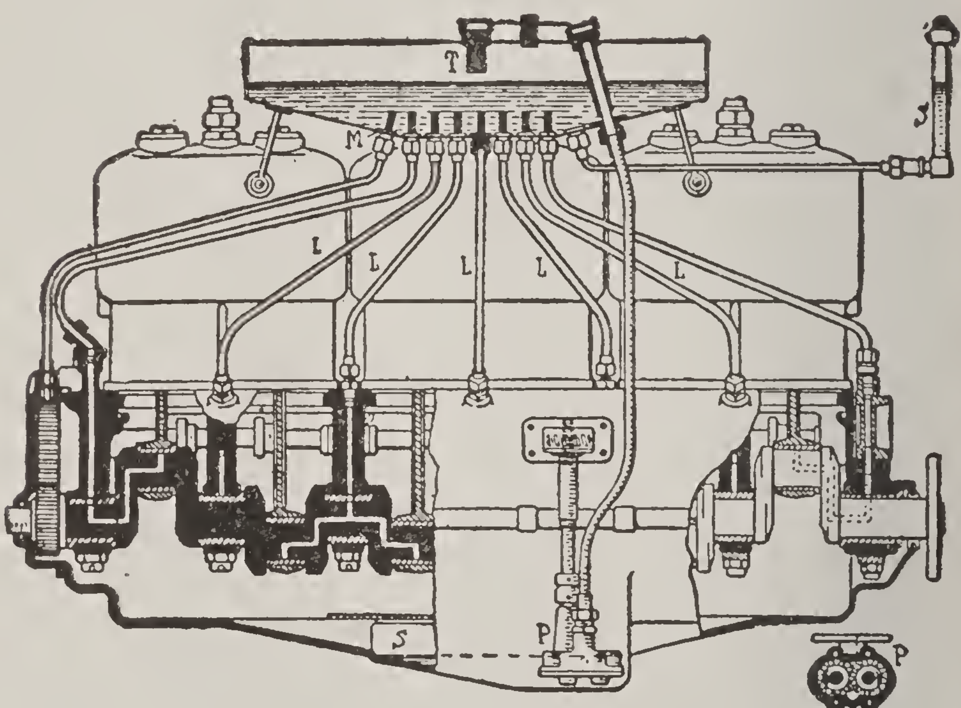


Fig. 200
Pierce-Arrow Oiling System

crankpins being sufficient to lubricate the cylinders. As there is always a mist of oil flying around in the crankcase, it is known as the "mist" system.

As shown in Fig. 200, the oil supply is carried in a sump S beneath the crankcase, and the crankcase bottom is sloped towards the center so that oil falling in it is immediately

drained into the sump. The gear pump P, driven from the camshaft through a vertical shaft, elevates the oil to a tank T carried above the cylinder heads, and from this a lead L passes direct to each of the crankshaft bearings. From these bearings the oil passes through the drilled crankshaft to the lower bearings of the connecting rods, whence any overflow falls into the crankcase, or is thrown into the cylinders in the form of a mist through the slot in the baffle plate, closing the lower end of the cylinder to prevent an excess of oil getting on the walls. This mist not only cares for the cylinder walls, but also oils the wrist-pin bearing. The flow of the oil through the leads L from the tank to the bearings is regulated by thimbles M, inserted in the upper ends of the leads where they enter the oil tank, and in each thimble is a small opening which allows only a limited amount of oil to flow. The size of the openings in the thimbles is varied to suit the demand of the bearings for oil.

FLYWHEEL OILING SYSTEMS. In the Ford flywheel system of oiling illustrated in Fig. 201, the flywheel casing serves as an oil reservoir, and the rotation of the wheel throws the oil up into pockets, from whence it is conducted through pipes to the crank-case. The angle of the pipes is such that even on extreme grades there is sufficient drop to insure a flow of oil. A depression M is found in the crank case beneath each connecting rod, in order to limit

the amount of oil carried in the crank case, and also to insure an even level of oil within the case.

Royal Tourist Double System. Two entirely separate methods of lubrication are used in this

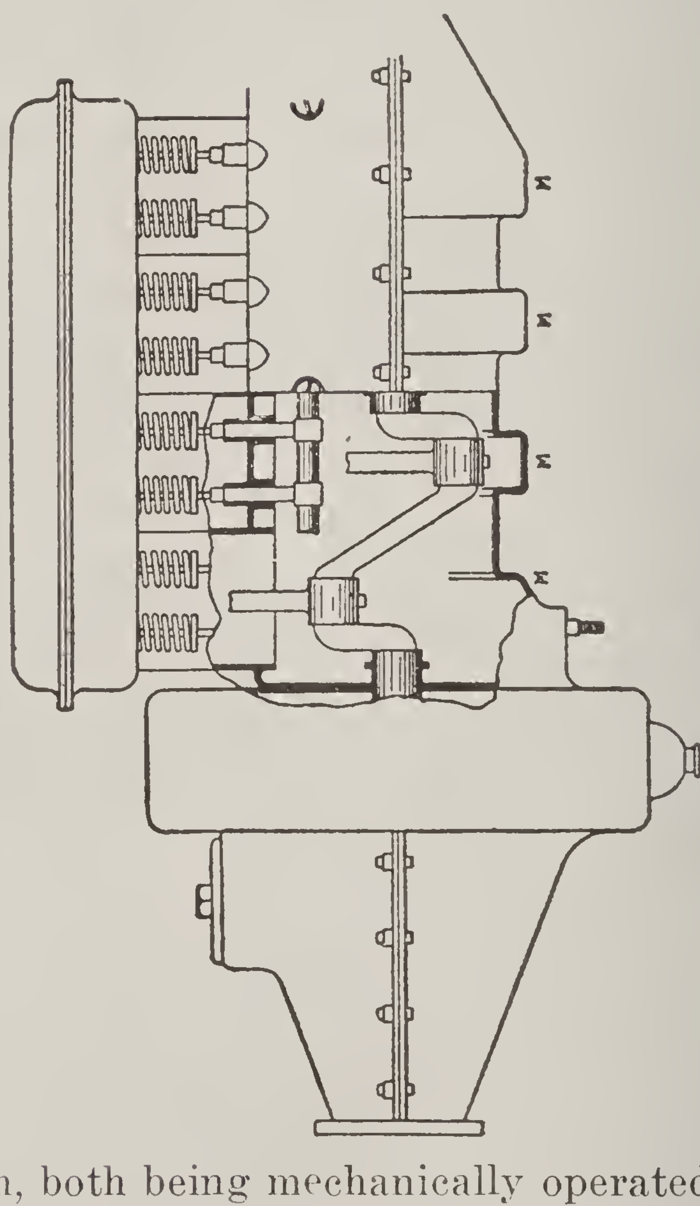


Fig. 201
Ford Flywheel Oiling System

system, both being mechanically operated. The two methods are, the mechanical oil feed to main bearings and constant level oil splash, and sump and pump system. In the first, a mechanical oiler A, Fig. 202, is located under-

neath the dash, so that its sight feeds may be seen where the dash joins the foot boards. This oiler draws its supply from a three gallon tank T, located under the front floor boards, and delivers it through leads to the three bearings B of the crank shaft. The crank case has a horizontal partition forming an oil reservoir R, and leaving the upper compartment C, into which

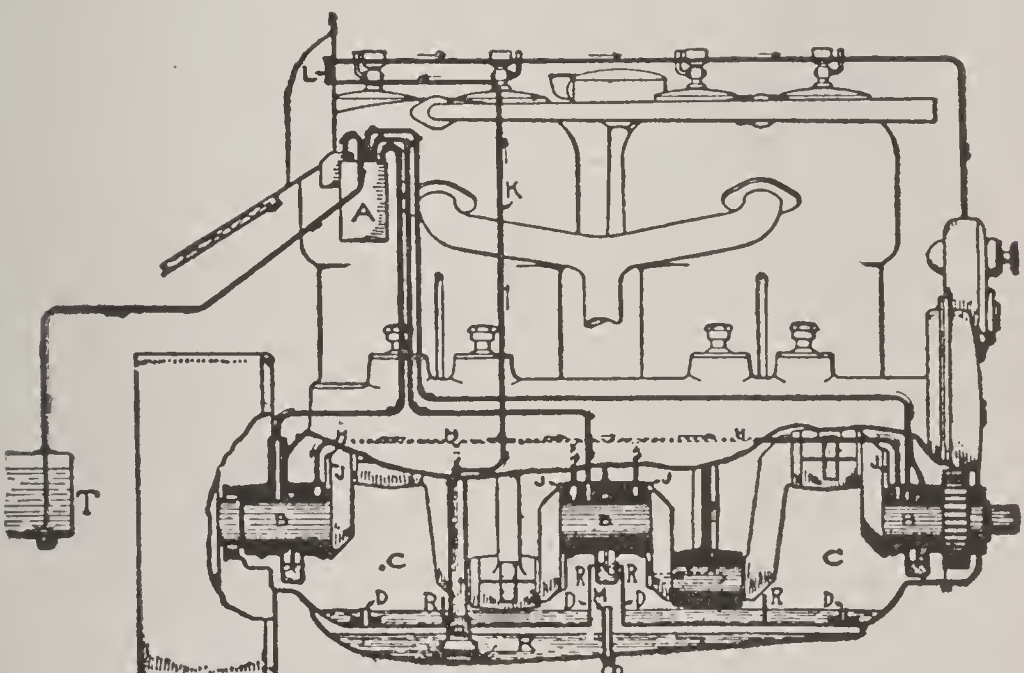


Fig. 202
Royal Tourist Double Lubricating System

the connecting rods dip in the oil level it carries. The oil level in compartment C is equalized by three transverse ribs R, and the oil is prevented from getting above a certain level by holes D in standpipes, through which the oil overflows into reservoir R.

In the second system a small gear pump G in the reservoir R discharges upwards along its

driveshaft to an oil pipe H, which has a branch running to the inner end of each crankshaft bearing. By means of holes drilled in the bushings the oil is squirted into oil catches, J, J, J, J, that revolve with the crankshaft and feed the oil through holes drilled in the crankpins to the lower connecting rod bearings. In addition the catches J receive the overflow oil, which works from the main crankshaft bearings. From the gear pump a lead K passes through a sight feed L on the dash, and thence leads to the compartment housing the half-time gears at the front end of the motor. A ring is fitted on the bottom end of the piston to prevent an excess of the oil from the cylinders. In oiling the wristpins, which are tubular, the ends are plugged, and the hollow thus formed receives oil from a recess cut in the outer wall of the piston at this point, which oil feeds to the bearing, which is in addition to all pumped up through tubes in the connecting rods.

Winton Double Pump Oiling System. The six-cylinder motors used on the Winton cars are lubricated by a double pump method, the pumps being driven by an eccentric off the end of the crankshaft. The usual sump is replaced by a tank. As shown in Fig. 203, one pump P draws the oil from a tank T by lead L' and forces oil to all of the crankshaft bearings, to the timing gear-case, and a sight feed S on the dash, the oil going from the pump through one lead N to a distributing manifold M at the

side of the motor. The other pump P delivers this oil back to tank T, from which it was first drawn, thus causing a constant circulation of oil.

The main oil reservoir is located on the left side of the motor base, and the surplus from the crankshaft bearings falls into the splash, which, instead of being allowed to increase, is drained off by a collector tube H to an oil well W, from which it is drawn by the pump P, and returns to the tank T. With this system the

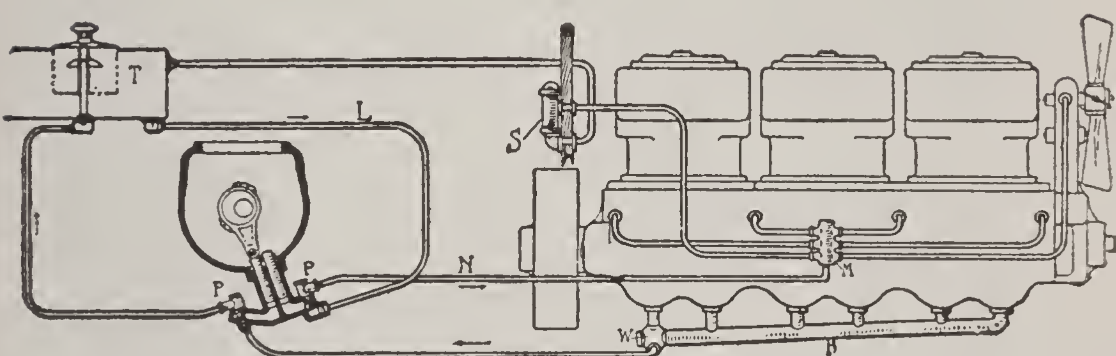


Fig. 203
Winton Double Pump Lubricating System

crankcase is comparatively dry; the lower connecting rod bearings are oiled by drilling the crankshaft and the cylinder walls and upper wrist pins by the splash from the overflow of the connecting rods and what oil may be picked up from the crankcase. A strainer in tank T is used to strain all the returned oil before it is used again.

Drilling Oil Passages in the Crank Shaft. Figs. 204 and 205 show two different methods of drilling the crankshaft to convey the oil to

the crankpins, and it will be noticed that the oil holes discharge at the highest point of the revolution, corresponding to the position of the piston at the beginning of the power or firing stroke. The supply is received by the main bearings from the oil pump and the oil hole in the shaft, coinciding with that from the oiler has a little oil forced in each revolution and, generating centrifugal force throws it rapidly through the passages. The majority of modern motors are equipped with splash lubrication and have the connecting rods dip into the oil

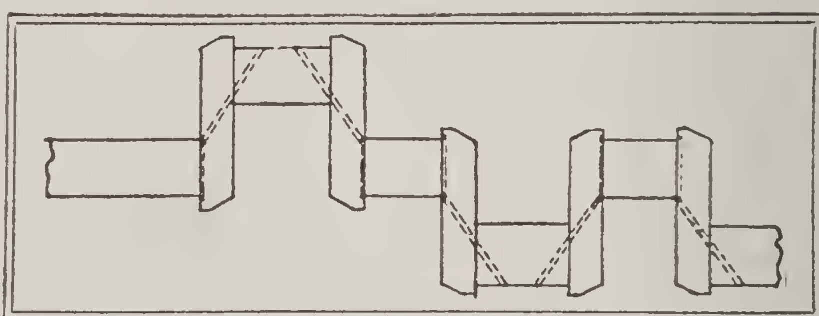


Fig. 204

each revolution and splash it all over the inside of the crankcase. Some types are equipped with a scoop pointing in the direction of rotation, at the lower end of a passage connecting with the crank pin. The oil is sent into these passages with considerable force, owing to speed of rotation, thus assuring sufficient oil to the connecting rod bearings.

This is worked to the ends of the bearing and thrown off in the shape of a fine mist that penetrates to every part of the crankcase. The oil splashed onto the lower cylinder walls and not

carried up by the piston is caught in little troughs, cast in the crankcase and drilled so that the oil runs down to the main bearings. In addition to the pipe from the oiler, the better designs provide an oil wick, or an oil ring or chain, all types carrying oil from a shallow pocket corded in the bearing cap, the wick by capillary attraction, and the ring or chain, revolving with the shaft, their lower ends immersed in the oil will carry up a considerable quantity that will spread over the shaft. This

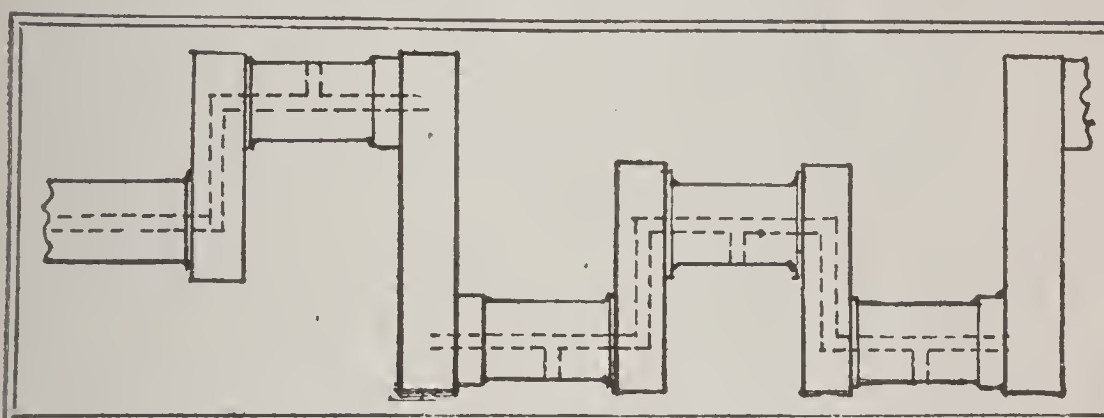


Fig. 205

oil ring system is used very successfully in electrical machinery. With a splash lubrication it is advisable to drain the crankcase at frequent intervals, and also to put in a fresh supply of oil.

Lubrication of Gears and Clutches. The modern ball-bearing gear box requires but little attention. Periodic filling with suitable lubricants is sufficient. On chain-driven cars the gears and differential are usually exposed by lifting one cover. On shaft-driven cars the

differential and rear axle system requires a certain amount of attention, as too much oil in the differential is liable to leak through the axle sleeve and hub, usually getting on the brake drums. If this happens, the best thing to do is to jack the wheel up and squirt gasoline on the drum, slowly revolving it meanwhile. Manufacturers usually put a plug in the differential case showing the proper height at which to keep the oil level. The gear box should be kept a little less than half full. If too much is put in. the oil will be thrown out of the shaft and bearing housings, but a little leakage does no harm as there is always dust present and the oil leaking will serve to fill the crevices and make the case dust-tight. In regard to the wheels, universal joints, clutch, and many little places about the car, all need attention occasionally as almost any motor car driver knows.

The wheels should be cleaned and packed with grease once or twice a season, universal joints at intervals necessarily shorter. Latest designs provide for their lubrication through the shaft from the gear box. Earlier types are best packed in grease and enclosed in a leather boot. On many shaft-driven cars, where the shaft runs through a sleeve, daily attention should be given. The lack of a few drops of oil may rob the car of 50 per cent of its power. Multiple disc clutches use oil, or an oil and kerosene mixture, and the tendency seems to be

for the oil to gum. Their action when slipping or dragging is sufficient indication as to when they are in need of attention. Leather-faced clutches will work much better when cleaned with kerosene and given a dose of neatsfoot or castor oil. The oil should be spread over the surface of the leather by using a long knife blade, or by running the motor for a few moments with the clutch released. When treating the clutch leather this way it is better to let it stand over night if possible, and with the emergency brake lever, or a block of wood against the pedal hold the clutch disengaged. A hand oil can with a long spout is almost indispensable, and the starting crank, the steering pivots and connections, and the spark and throttle connections, gear control and emergency brake levers, clutch and brake pedals, shafts and connections and the fan bearings will all work much quieter and sweeter for a few drops of oil regularly. It is the practice of drivers to fill the oil can from the cylinder oil supply and this practice is to be commended, as many lower grade oils contain acids enough to etch steel.

Magnetos. The basic principles upon which the magneto operates have already been explained under the head of Generators, and need not be again alluded to. Several of the leading types of magnetos in use on modern automobiles will be described, and their action illustrated and explained.

Wiring Diagrams. In Fig. 206 is shown a wiring diagram of a high-tension magneto for a four-cylinder motor. In a true high-tension magneto the current is transformed from the comparatively low-tension current delivered by the magneto armature, to a high-tension current of sufficient pressure to overcome the resistance of the air gap between the electrodes of the spark plug, by means of a secondary winding

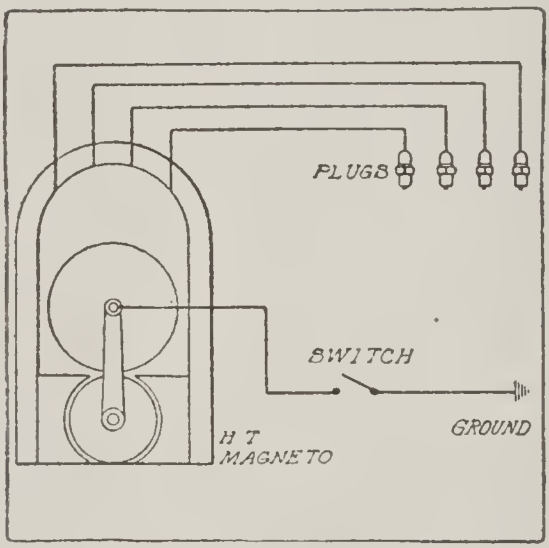


Fig. 206

on the armature itself. Thus the whole apparatus is self-contained, and requires no separate transformer coil, which greatly simplifies the wiring. There are only five wires leading from a high-tension magneto for a four-cylinder motor; four of these lead to the spark plugs, and one to the ground. The switch is placed on the ground wire, and when closed, short-circuits the primary current of the magneto and prevents the induction of a secondary current, thereby

stopping the sparking at the plugs. In Fig. 207 a low-tension system is shown. This is more simple than the wiring of a high-tension system, only two wires leading from the magneto —the one carrying the current to the insulated terminals of the make and break, or magnetic plugs; and the other being a ground wire, which unlike that of the high-tension system must be opened to stop the motor. A wiring

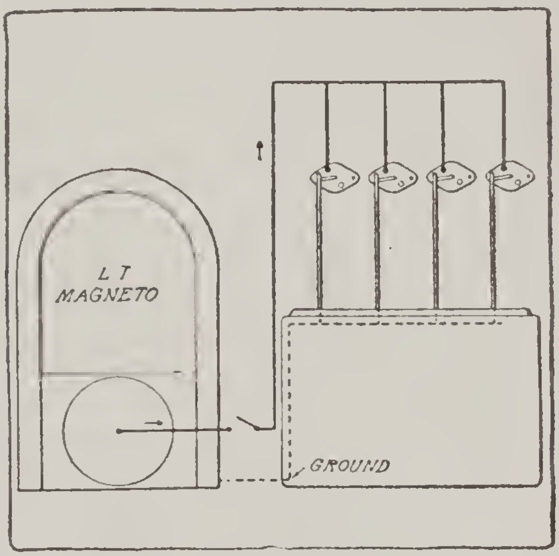


Fig. 207

diagram for a two-cylinder motor with a single coil and distributer is shown in Fig. 208.

MAGNETO—BOSCH LOW-TENSION. The Bosch electro-magnetically operated spark plug is illustrated in Fig. 209 and Fig. 210. It consists of a coil A, one end of the winding of which connects with a terminal B and the other with the plug casing C which threads into the cylinder of the motor. A spark is produced when a separation takes place between the moving

contact D and the stationary contact E on the end of this plug, which separation is accomplished in the following manner: Within the plug is a metal core F and a swinging lever G, which lever pivots on the knifed edge projection H which is a part of the core F. K shows a portion of a hair-pin spring, the end L of which rests in a recess with the lever G, the ordinary tension of the spring tending to hold the lower end of the lever G carrying the contact

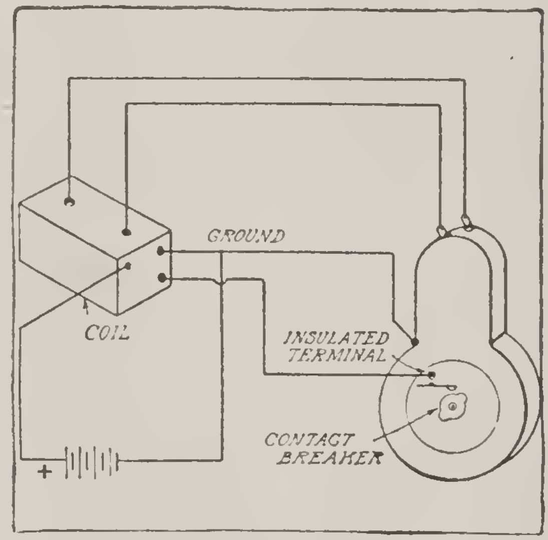


Fig. 208

D against the stationary contact piece E. The operation of the plug is briefly as follows: When the distributer forms a contact for giving a spark to any cylinder, the circuit through the plug is through the contact B and the coil A, thence through the plug casing C and back to the motor. The completion of the circuit energizes the core F which tends to pull the upper end M of the lever G towards the right, but it is protected from contact into the core by the

non-magnetic brass plug N. The pulling of the upper end of the lever G to the right carries the lower end to the left, separating it from the stationary contact E, thereby breaking the cir-

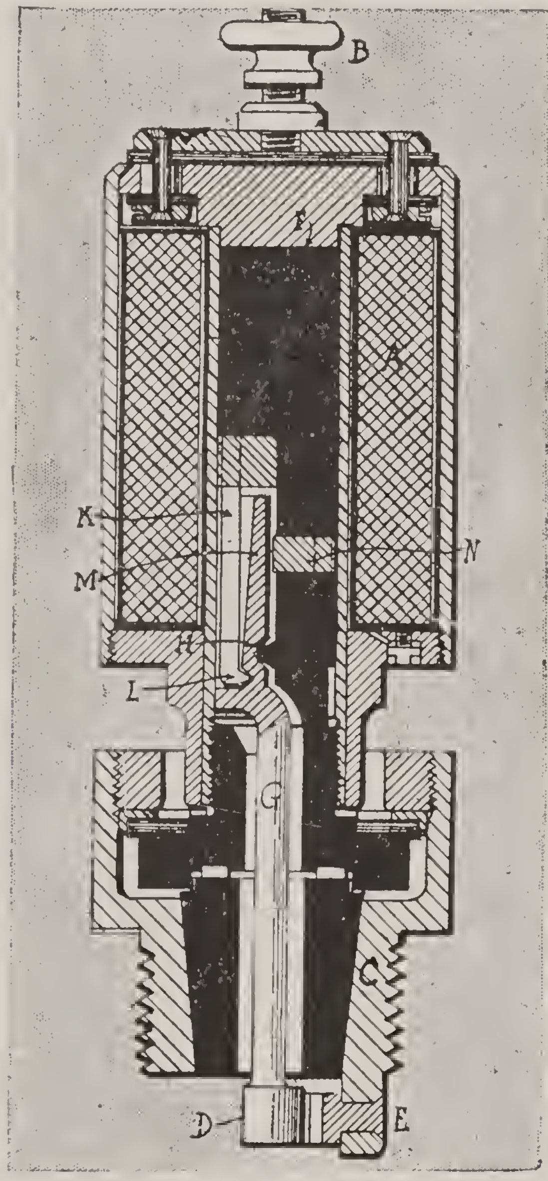


Fig. 209
Bosch Electro-Magnetic Plug

cuit. Immediately the circuit is broken the coil A surrenders its electro-magnetic power, the core F is degenerized and the end of the hair-pin spring L forces the lower end of the

lever G to the right, as the spring L exerts its pressure beneath the fulcrum H and which brings the contacts D and E together. At the

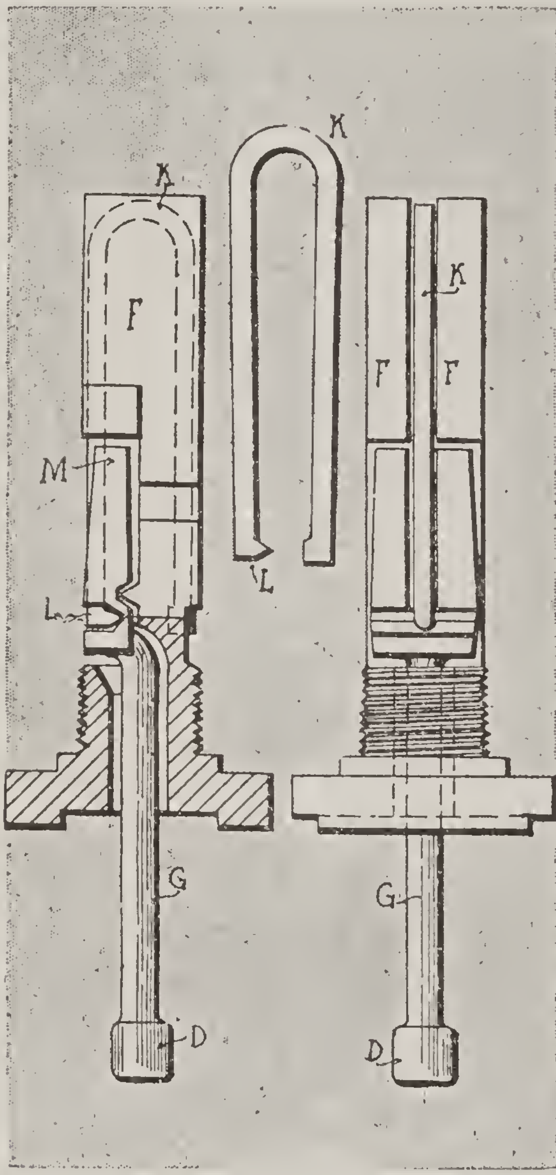


Fig. 210
Assembly Bosch Plug

bottom of the contact piece there is an insulated fixed stem which is magnetically divided in about the middle by means of a brass part, so that when the current passes through the

coil A only the portion of the stem above the brass part can be magnetized, and, as a result of this magnetization the upper end M of the interrupter lever G, which directly faces the magnetized part, is attracted, the lower end D

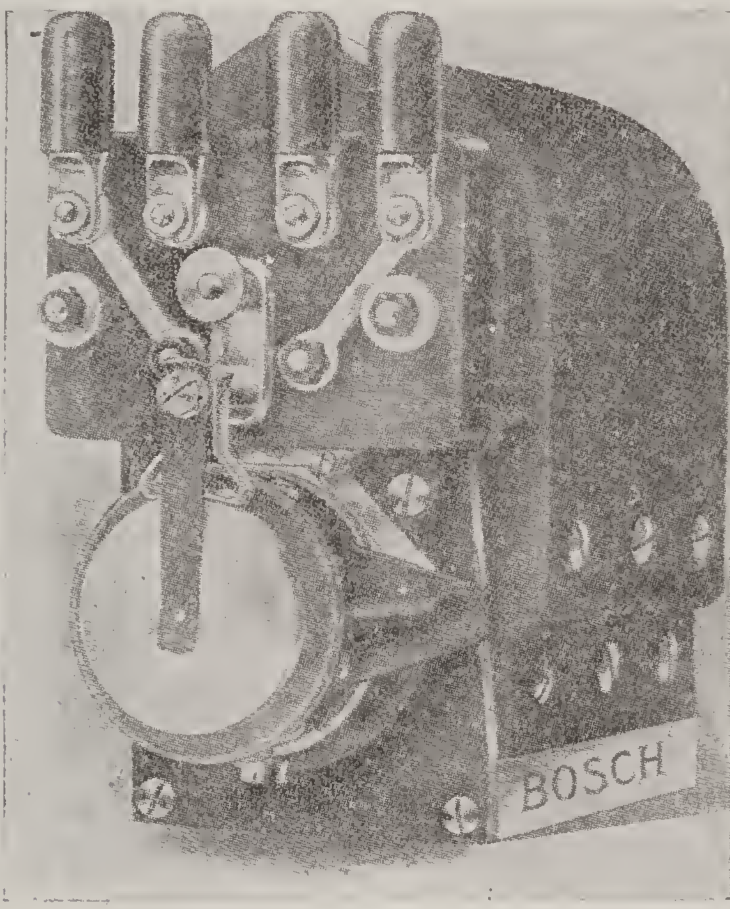


Fig. 211
Bosch Magneto

simultaneously breaking contact with the contact piece E, thus interrupting the current and producing a spark. In the normal position of the interrupter lever G. the lower end presses against the contact piece E. being kept in that position by the horseshoe-shaped spring K,

which passes right over the top of the stem and lies in slots in the sides thereof.

The top of the coil is fitted with a contact screw to which the current from the magneto is led. This magneto, Fig. 211, generates an ordinary low-tension current and is provided with a low-tension distributer distributing the current to the individual plugs, according to the number of cylinders, so that only one low-tension wire for each plug is employed. The distributer disc is shown separately in Fig. 212, as well as the interrupter, which latter is provided for the purpose of timing the ignition.

Regarding the magneto of Fig. 211 as used for the plug, Figs. 209 and 210, it is of interest to know that the magneto is made for three, four and six cylinder motors, the distributers having corresponding numbers of pick-up carbon brushes and terminals. Their armatures are driven at three-quarters, equal, and one and a half turns of the crankshaft respectively; each is made in two patterns, according to the direction of rotation, which should be stated when ordering. The range of timing is about 60 degrees, 50 degrees, and 34 degrees, relatively to the crankshafts of the three types of engine. The lever has a certain amount of side play, so that if two of the contact surfaces at D become fouled, a slight scraping action is set up between the other two, and a good conductor is assured. Not only must the magnetic plugs be set vertically, but they must

be arranged where their metallic exteriors are clear of other parts, and also where they can be kept cool.

Fig. 213 is a diagram of the electrical arrangements, which will be seen to be similar to those of the Bosch high-tension magneto. A portion of the wiring of the armature is short-

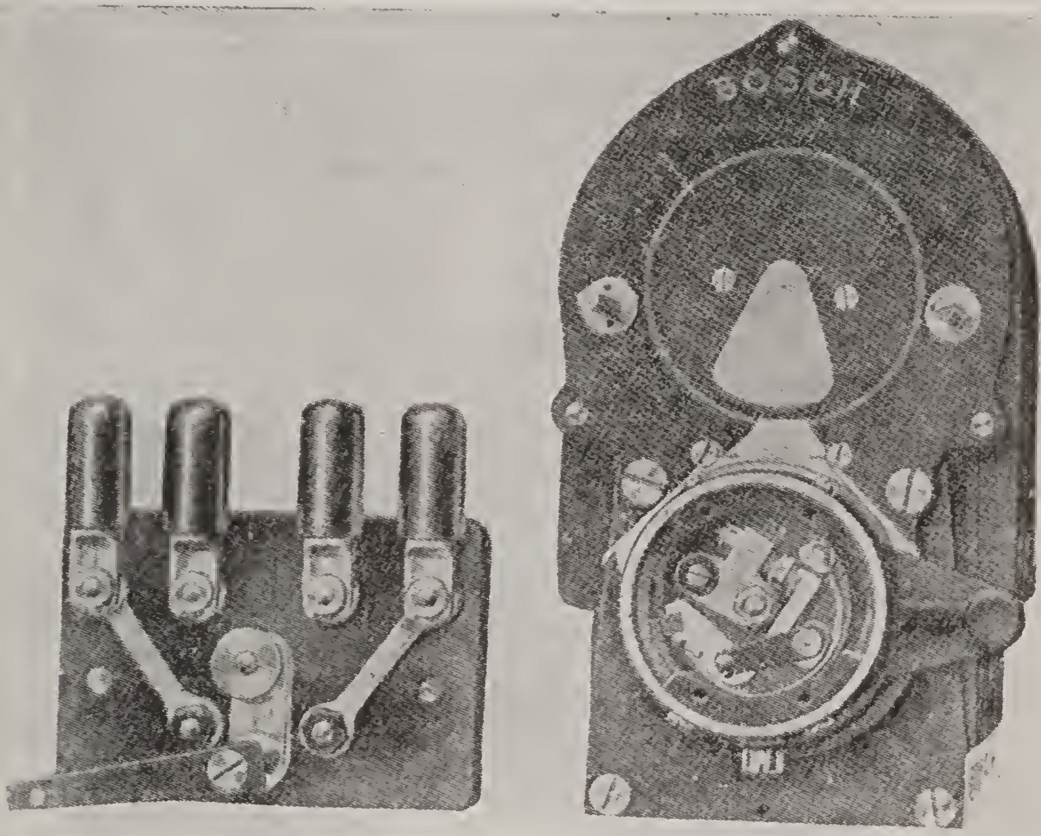


Fig. 212

circuited by the platinum points of the interrupter, and when the circuit is interrupted, the resulting armature reaction has the effect of raising the voltage of the armature sufficiently to operate the magneto plugs. The rotating distributer bar is adjusted in such a manner that it is always in connection with one of the

spark plugs at the moment when the contact breaker of the magneto interrupts the circuit, so that the circuit to the plugs is closed and these are magnetized for operation. The spark is advanced or retarded by rotating the timing

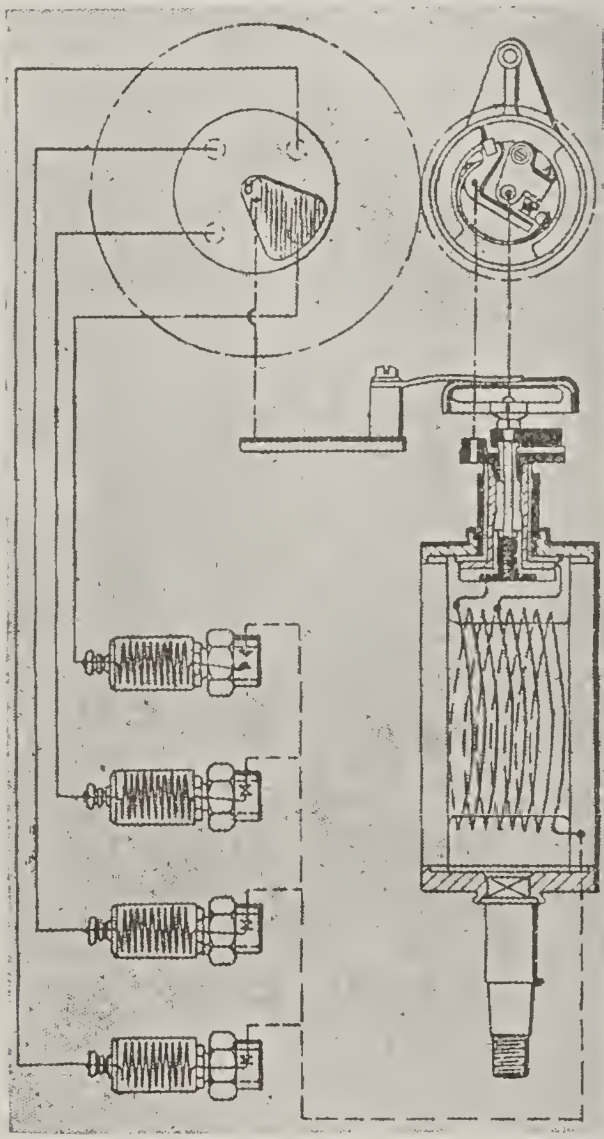


Fig. 213
Diagram of Bosch Electrical Arrangement for Motor Car

lever, in the same manner as with a high tension magneto, and the timing corresponds to an angle of 50 degrees on the armature shaft. The magneto is switched off in the same manner as a high-tension magneto, by making a ground

connection. This is done by small plug switches with either a single plug, or a number of plugs corresponding to the number of cylinders. This makes it possible to switch each cylinder out

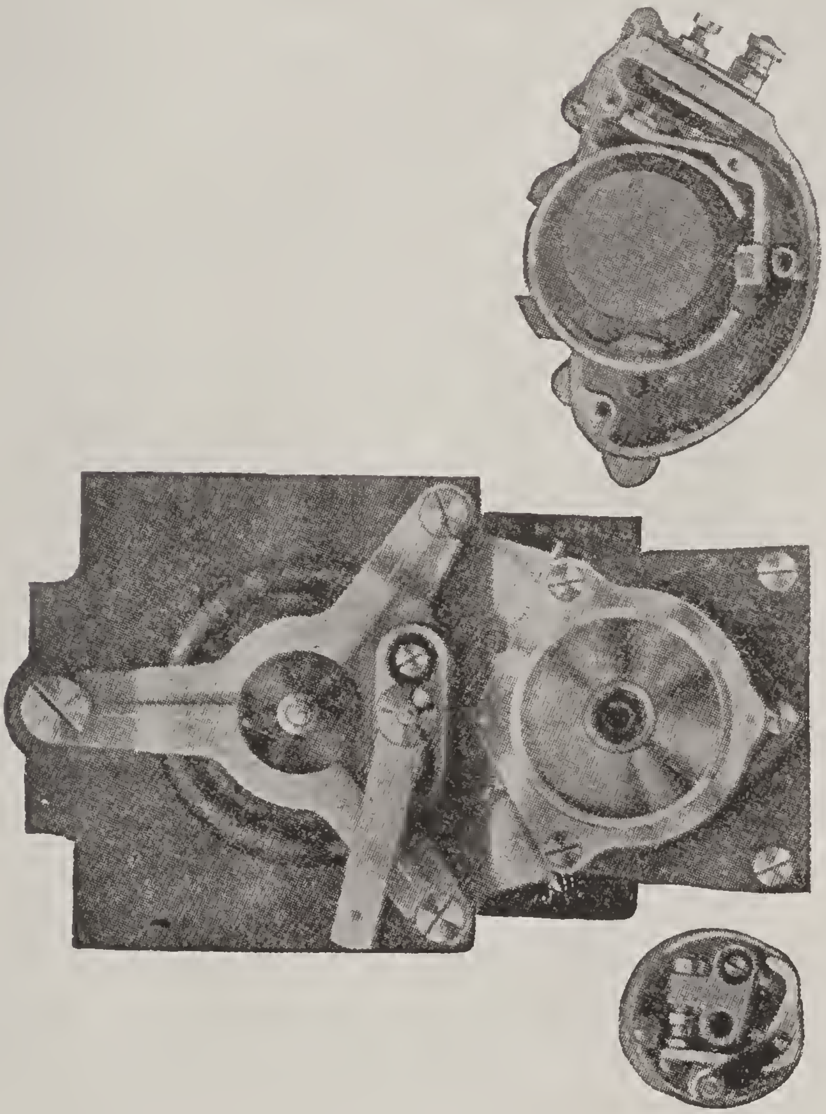


Fig. 214
Details of the Bosch Magneto

separately for testing purposes, from the seat while the car is in motion.

MAGNETO—BOSCH HIGH-TENSION. The Bosch high-tension magneto, or generator differs from the standard rotary armature type in two respects only. First, the high-tension connec-

tions are slightly altered, and, secondly, an additional contact breaker for the battery is provided as shown in Fig. 214, so that the magneto will also serve as a timer for the battery, while the one high tension distributer is used with both the magneto, and the battery current. All other details of the high-tension system are similar to those of the low. A special coil is provided for battery ignition, having a self-contained switch, and button for bringing a

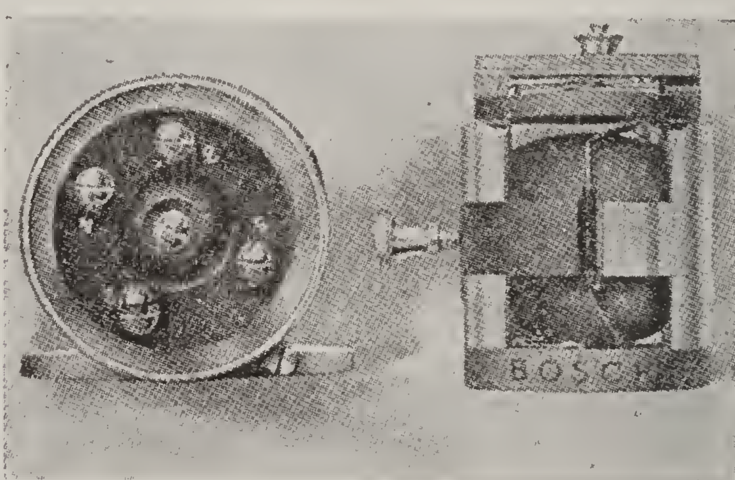


Fig. 215
Bosch Armature

magnetic vibrator into circuit when desired, for the purpose of starting the motor from the seat when there is any gas in the cylinder. The coil is of the general form of an H armature, see Fig. 215, and not of the usual cylindrical form with concentric windings. It possesses the same amount of self-induction as the magneto armature, and while the engine is running, the two systems are absolutely synchronized, and no difference is apparent in the speed

of the engine, whether the magneto, or the battery is used for furnishing the spark.

The trembler is used only at the moment of starting. The button switch for bringing it into circuit is fitted in the lid of the case in such a manner as to render it water proof. The

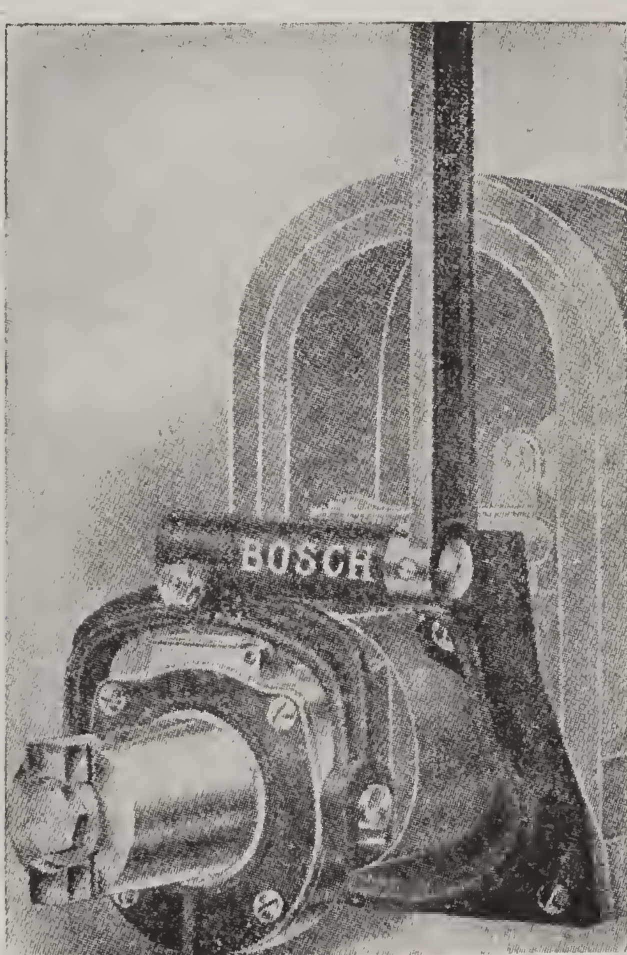


Fig. 216

connections are made by small segments in the bottom plate of the coil frame, the entire coil being moved toward the left, or the right to effect a change over. The switch handle projects through a circular slct in the housing, and locks in three positions, designated respect-

ively, "Magneto," "off," and "battery." For inspection purposes, unscrew the switch handle, and remove the lid, when the coil may be taken out without disconnecting any wire. On some machines, particularly racing autos, a large

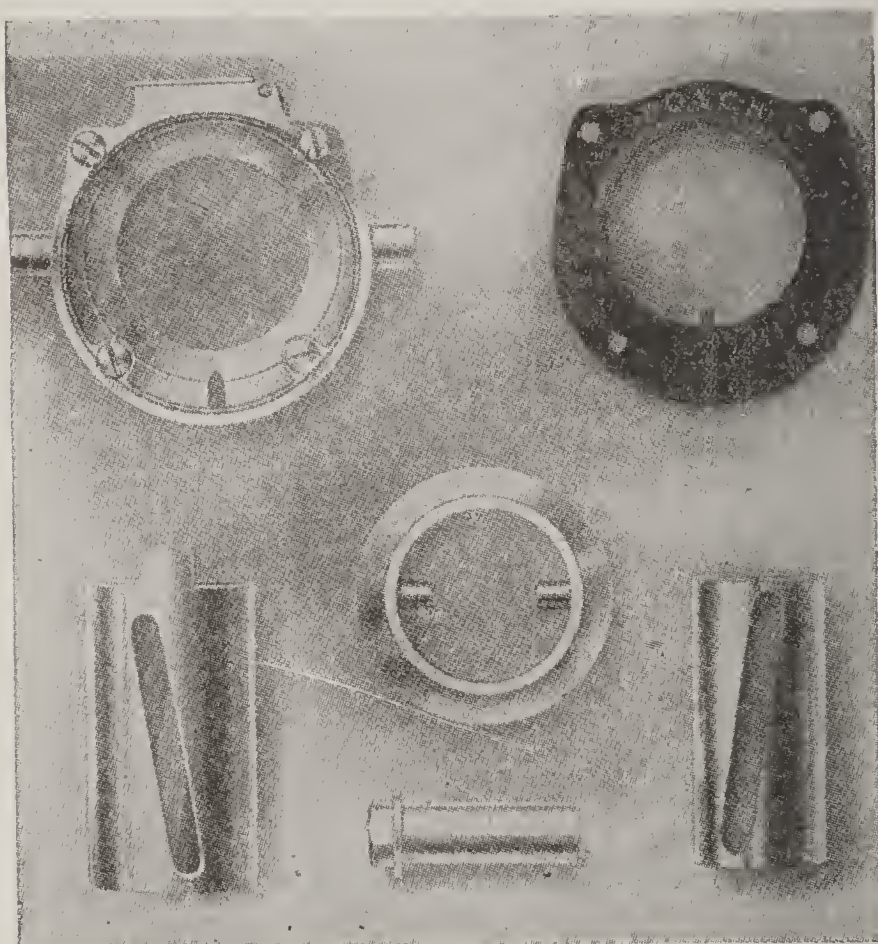


Fig. 217
Coupling Device for Bosch Magnetos

timing range is required. This necessitates the shifting of the magneto armature with respect to the driving shaft, which can be done by means of the coupling shown in Figs. 216 and 217. In Fig. 217 are shown two rotary sleeves, one fitting into the other, both being provided

with helical slots running in opposite directions, so that by removing the collar that carries pins which extend into the slots, an angular movement of these sleeves relative to each other up to 60 degrees is obtainable.

EISMANN MAGNETO. There are two types of the Eismann magneto. First, the low tension magneto requiring a transformer to raise the voltage of the current; and second, the high tension magneto, which has a double winding on the armature and does not require a non-vibrator coil.

The low tension magneto gives off from 20 to 40 volts only. One end of the armature winding is grounded, the live end passing to the insulated contact of the interrupter, which is located at the end of the armature shaft. From this point the circuit continues to one terminal of the primary winding of the coil, the other terminal of which is grounded. The grounded part of the interrupter, a pivoted lever, is operated by a cam carried on the armature shaft, and makes and breaks contact with the insulated part. The cam is set in such relation to the armature that the breaking of the circuit by the interrupter coincides with the production of maximum current in the armature winding. When the interrupter is making contact, the magneto current is offered two circuits by which it may flow to ground, one being through the interrupter and the other through the primary winding of the coil. The

resistance of the former being low, the current takes that path in preference to the other, which is of higher resistance. When the current reaches its maximum the cam breaks the interrupter circuit, and the only path by which the current can then flow to ground is that offered by the primary winding of the coil. This sudden and intense flow causes the core of the coil to throw out a powerful magnetic field,

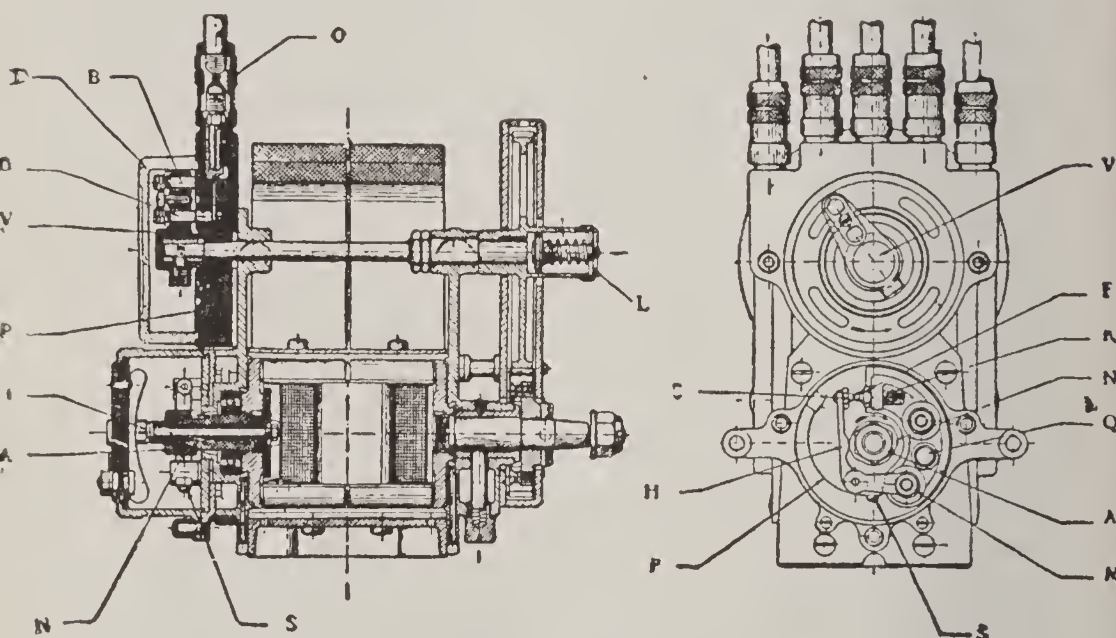


Fig. 218
Eisemann High-Tension Magneto

which induces a current in the secondary winding of from 20,000 to 40,000 volts. This current is passed to the proper spark plug through the medium of a distributer located on the magneto and driven by the armature shaft. A condenser is connected across the interrupter contacts to reduce the sparking as the circuit is broken, and to effect a more abrupt change in the magnetic field of the coil.

The latest Eisemann magneto is of the high-tension type, as shown in Fig. 218, in which A is the cam nut; B, steel contact for high-tension distributer; C, platinum contact for make-and-break lever; D, high-tension distributer

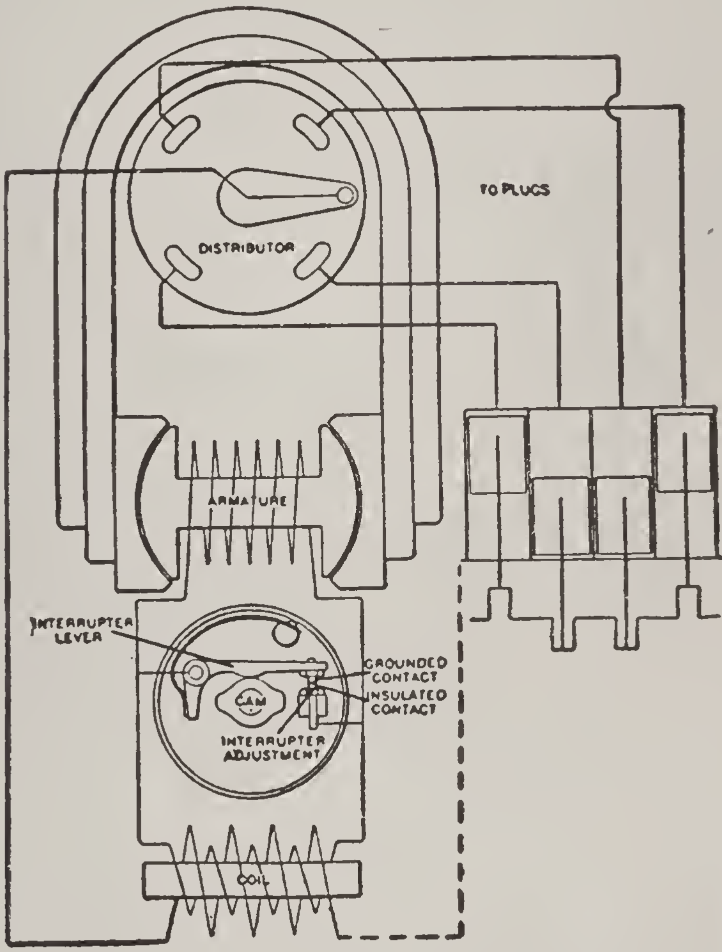


Fig. 219
General Wiring Diagram for Eisemann Magneto

cover; E, nut for adjustable contact screw; F, spring for make-and-break lever; G, carbon contact for high-tension distributer; H, make-and-break lever; I, low-tension carbon brush; K, adjustable platinum contact screw; L, grease box for large toothed wheel; M, nut; N, cam:

O, cable joints; P, distributer plate; Q, metal contact; S, screw for spring for make-and-break lever; V, high-tension distributer.

Magnetos are made to turn in either direction, but the magneto once finished turns in one direction only, and this direction is indicated by an arrow placed on the gear wheel case.

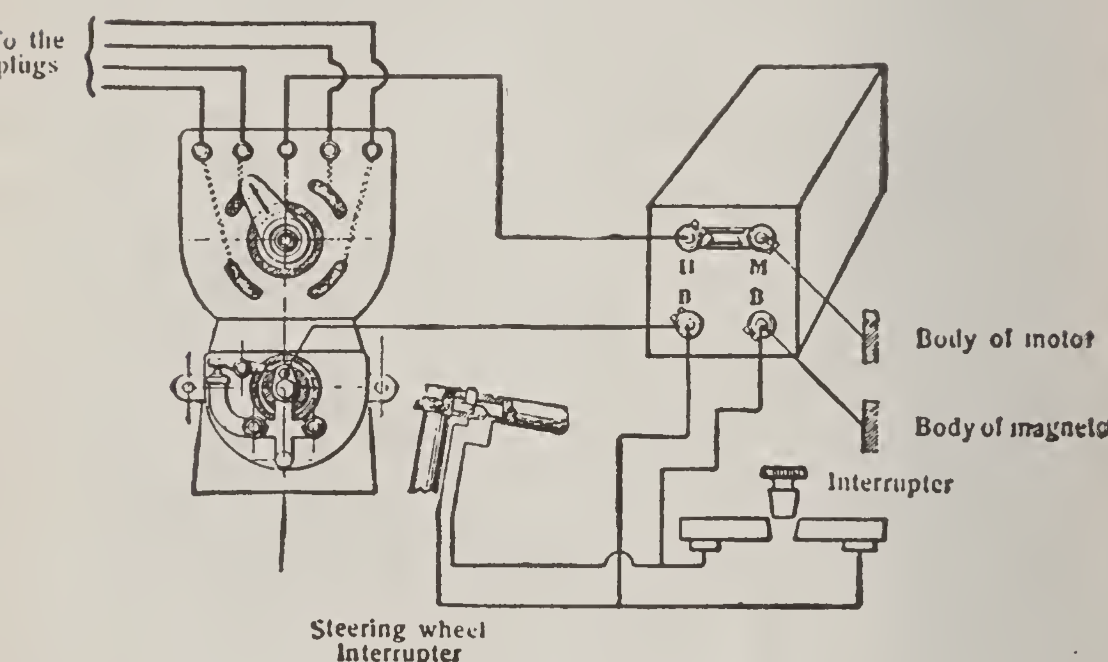


Fig. 220

The spark occurs in one of the cylinders at the moment that the contact points are separated by the cam. The advance mechanism is arranged in three different ways : (1) by means of a lever working the make-and-break mechanism (quadrant advance); (2) by means of a piston sliding longitudinally, and fitted to the end of the driving axle (piston advance); (3) by rocking the magnets bodily around the ar-

mature (pivoting advance). In all cases a displacement of 45 degrees can be obtained. In magnetos with quadrant advance the driving spindle is fixed by means of a pin and nut.

This type of magneto is consequently shorter than the one with piston advance. In the latter case the driving pinion is fixed on a hollow spindle.

Timing the Eismann Magneto. When timing a magneto with quadrant advance, push lever as far as possible in the direction of rotation (looking from the driving end). In this position the time of ignition is "fully retarded." Turn motor by hand until the piston of the engine, corresponding with the metallic contact piece on which presses the distributer finger, has gone a very small distance beyond the dead point. Turn armature of magneto until the line which is marked on cam stands right opposite the pin screwed into bearing plate (moment at which spark takes place). Fix driving pinion in this position. By gradually displacing the lever it is possible to give the motor the required spark advance.

When timing a magneto with piston advance the timing of the ignition is the same, whether the magneto is turning clockwise or otherwise. Pull out the piston (retard), and proceed exactly as above described. By gradually pushing the lever into the hollow spindle the required advance is obtained.

When timing a magneto with pivoting ad-

vance, move the magnets as far as possible in the direction of rotation (retard), and proceed again exactly as with the quadrant advance. By gradually altering position of the magnets the required advance is obtained.

To start engine it is sufficient to give a sudden jerk to the starting handle at the moment a

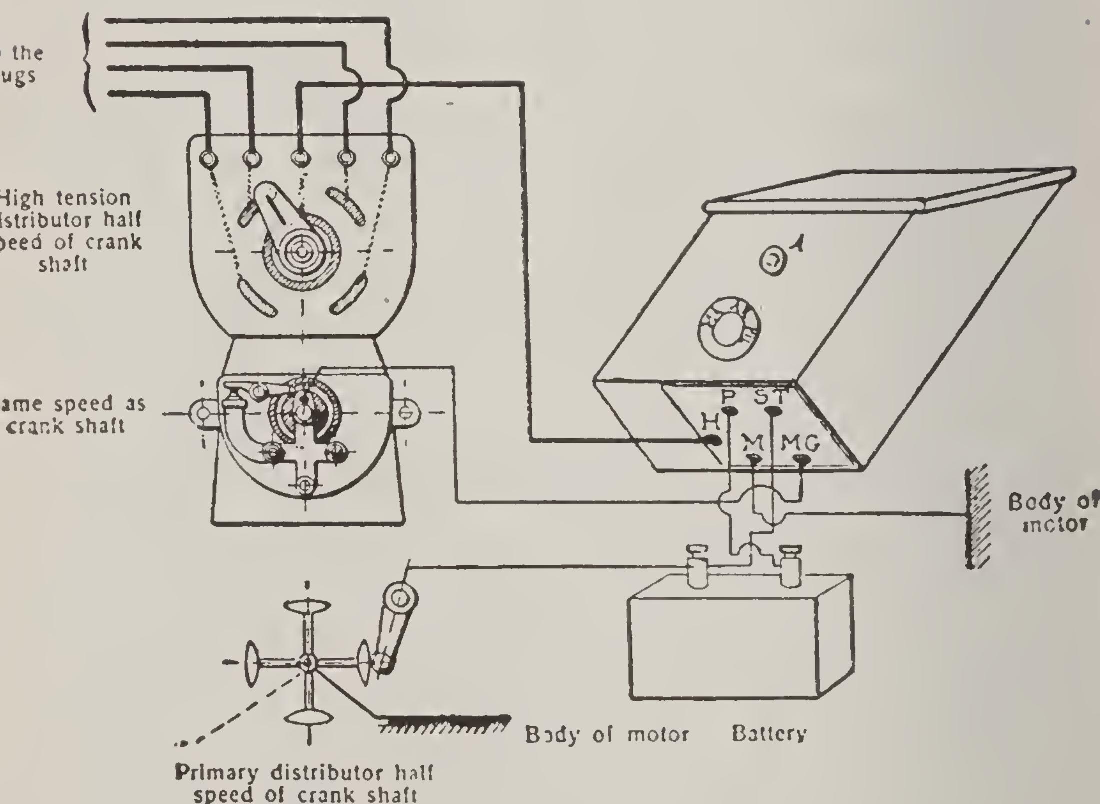


Fig. 221
Wiring Diagram for Eisemann Dual Ignition System

spark is to take place in one of the cylinders. If the motor does not start off at once, this may be caused: a, by the setting not being done in a proper way; b, by the points of the plugs being too much apart (about 0.5 millimeters); c, by the cables being faulty or the connections being badly made. Very often the carburation is

faulty. In any case care should be taken, when stopping the motor, to suspend the action of the magneto, and to cut off the supply of gasoline when the motor has ceased running. In this way the cylinders are prevented from getting filled with air. If the cylinders contain gasoline, the starting of the motor is always easy. If, on the contrary, the supply of gasoline is cut off while the motor is running, the

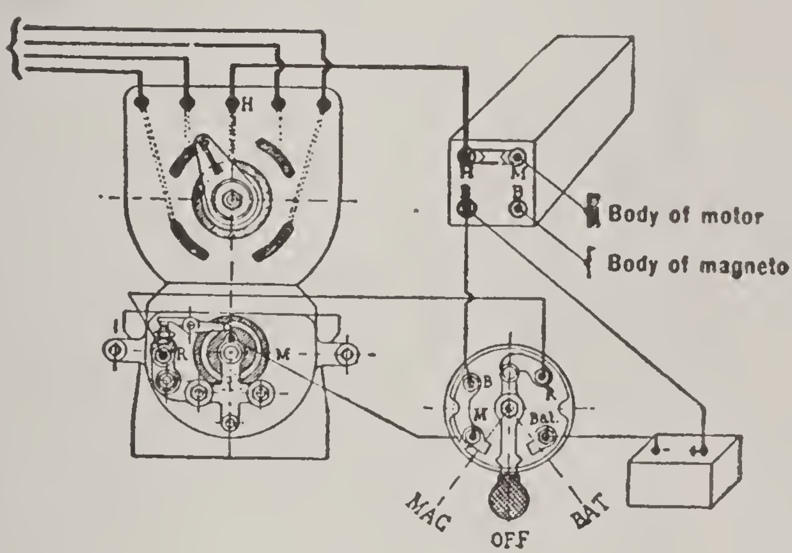


Fig. 222
Eisemann-Panhard Dual Ignition System

cylinders get filled with air, and on restarting it has to be driven out and replaced by gasoline.

Clean frequently with gasoline: a, the carbon brush at the end of the armature spindle; b, the platinum contacts; c, the metallic contact pieces in distributer disc.

If the platinum contacts are worn off, be careful that in setting or resetting them the contacts are not separated from each other more than one one-hundredth of an inch. In order

to facilitate the setting, two equal spanners must be used. Do the setting in the following way:

Loosen with one of the spanners the lower brass nut of the platinum contact holder, and then, by turning the upper brass nut, screw the platinum contacts upwards or downwards. If the adjustment is properly done, the contacts should be separated from each other, not more than one-quarter millimeter at the moment when the contact lever is raised by the cam. Then hold the upper brass nut with one of the spanners and fasten the lower brass nut with the other spanner.

If, for any reason, the magneto has been taken to pieces, be careful that when remounting same the numbers stamped on the gear wheels are exactly opposite each other. In case of any irregularity of the sparking, examine the magneto and coil in the following way: a, plugs. In order to find out whether the fault lies with the plugs, screw on new plugs and test the motor with them. b, cables. Examine whether all the cables are connected according to the wiring diagram. Make sure that they are not damaged, and that their ends do not touch each other or some metallic part of the magneto, whereby the current would be short-circuited.

On the type shown in Fig. 218, such as is used on the Packard 1909 car, the carbon brush at the end of the armature spindle inside the make and break cover, the platinum contacts

C and K, also the metal contact Q, and the metallic contact pieces in distributer disc should be frequently cleaned with gasoline. When setting platinum contacts C and K, or contact lever H, the circuit breaker should be taken off. Put through the hole in the plate, the

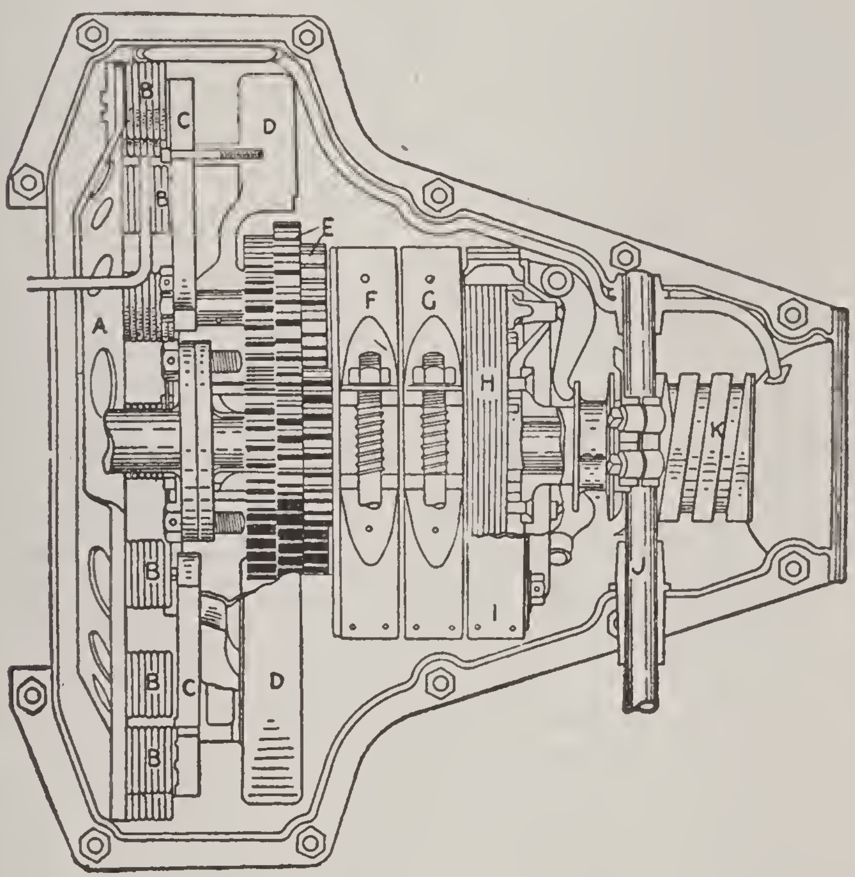


Fig. 223
Magneto Used on the Ford Cars

metal adjuster that is supplied with the magneto, and which has exactly the same diameter as the cam on the armature spindle. Then screw up or down the lower platinum contact K until a bit of paper can be slipped between the contact without getting jammed. In this

position the contact screw is held by means of a screw driver, while nut E is fastened.

Ford Magneto. The Ford magneto, Fig. 223, is of a peculiar design, it being constructed as an integral part of the flywheel, in which A is the support for the magneto coils; BBB, magneto coils; CC, permanent horseshoe magnets; DD, the flywheel; E, planetary pinions; F, low speed break band; G, reverse brake band; H, disc-clutch for high speed; I, transmission

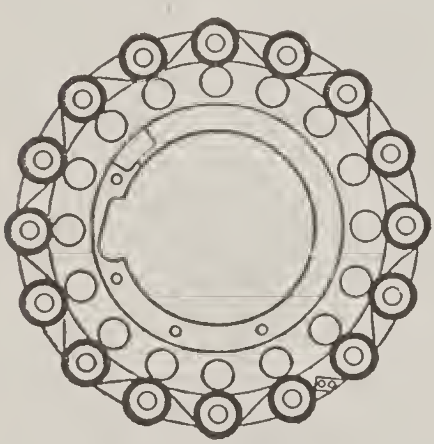


Fig. 224

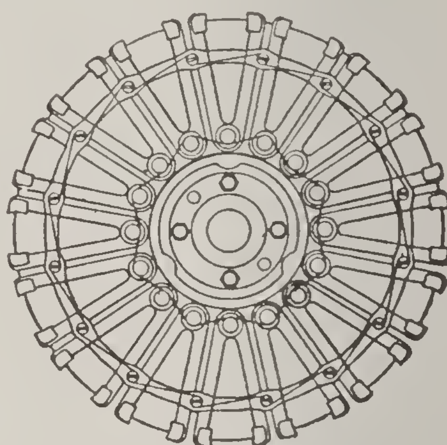


Fig. 225

Details of Ford Magneto

brake; J, clutch rocker shaft, and K, high speed clutch spring. The permanent magnets, which are U-shaped, are bolted to the forward face of the flywheel, as shown in Fig. 224. Close in front of their outer ends is a series of insulated coils mounted in a circle of practically full flywheel diameter, with their axes parallel with that of the crankshaft. They are supported upon a stationary spider, as shown in Fig. 225. As the flywheel revolves, this magnet and coil combination, which is similar to that used on some

types of alternating current generators, produces a current which is used through a four-unit current timer to cause the ignition spark. The magneto is of the inductor type, the armature coils being stationary, and the field magnets moved past them. Sixteen separate field magnets are used, made of vanadium-tungsten steel. They are substantially horseshoe shape, being secured to the side of the flywheel as illustrated in Fig. 225. They are held in place by screws at their middle, and by clamps near their poles, all screws used for fastening them being securely locked in place by wire locks.

The magnets are so arranged that, like poles, they are adjacent to each other, forming a sixteen pole field magnet crown. Instead of being placed close against the flywheel, these magnets are clamped against a ring of non-magnetic material (brass for instance), in order to reduce leakage of magnetism through the flywheel rim. At their middle these magnets are fastened directly to the flywheel, as at this point they are neutral, and there can be no leakage. A series of sixteen armature coils is carried on a coil supporting ring slightly in front of the flywheel, as shown in Fig. 224. These coils are wound with heavily insulated magnet wire, and are so grouped around the supporting ring that the winding of adjacent coils is in different directions, one being wound clockwise, and the next one counter clockwise. The coils are connected in series, the terminals being brought

out near the top of the casing. As the poles of the magnets are located opposite and very close to the coils, the magnetic circuits are completed by the cores of these coils and the coil support. There are evidently sixteen electrical impulses produced during the revolution of the crankshaft and flywheel, although only two impulses are required for the ignition of the motor, one per stroke. However, as the armature circuit is closed only when a spark is wanted,

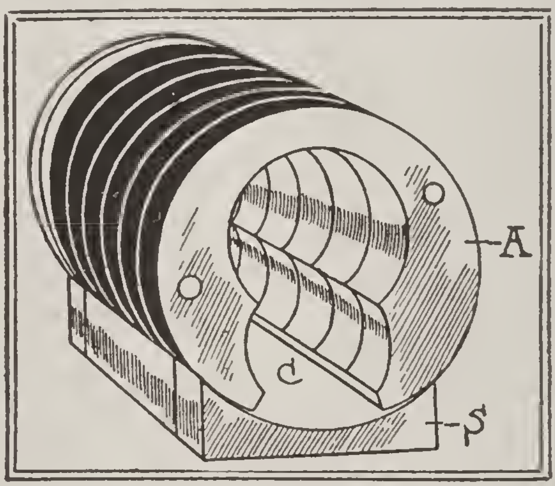


Fig. 226
Herz Magnets

a current only flows at that period, and there is no loss from the other impulses.

Herz High Tension Magneto. This magneto differs from the regular conventional type in that it is cylindrical in shape, due to the employment of ring-shaped field magnets A—Fig. 226—instead of the horseshoe type generally adopted. The six Herz magnets are in reality as many flat steel rings clamped together with a polar space, or armature tunnel, C, cut in

them. The ring surfaces are ground with the utmost accuracy in order to obtain the best magnetic effect when they are all clamped together. These magnets are mounted on an aluminum base S. A second unconventional-

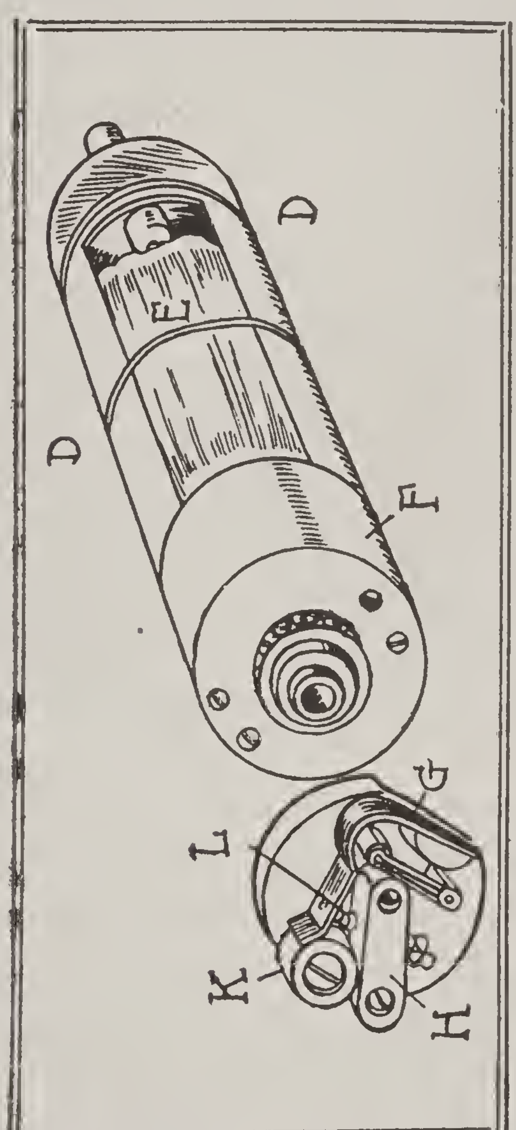


Fig. 227
Herz Make-and-Break and Armature

ity is that the usual independent, soft-metal pole pieces, which bolt to the ends of the horseshoe magnets in the conventional magneto, are dispensed with entirely. In the Herz system the space C, which accommodates the armature,

is bored out from the magnets A, and in this manner sharp angles in the magnet system, which invariably result in a leakage of lines of force in the magneto, are avoided. The armature D, Fig. 227, is of shuttle shape, accommodating the low, and high-tension windings E within the frame portion of it. So careful has the construction of this armature been superintended that there is but 1-10-millimeter air space between it and the curved portions of the magnets A. The armature revolves on ball-bearings, mounted in special cages, and is fitted with lubricating means sufficient for many months' use. The armature windings consist of a primary winding, in which is generated the low-tension current and also a secondary winding in which is generated the induced, or high-tension circuit. At one end of the armature, and encased in a brass box, is the condenser, F, Fig. 227.

The make-and-break devices for interrupting the primary circuit are illustrated in Fig. 227, the entire device being a detachable unit, which secures to the armature shaft by a key-way and feather. This make-and-break mechanism contacts with one end of the primary winding of the armature through a small carbon brush, fitted into the contact disk, which presses against a ring alongside of the ball race on the armature. The contact device consists of three parts: First, a curved spring G, having a platinum flat contact on one end; a steel block H

carrying an adjustable platinum contact, and a small, hard-fiber roller K carried on a pin. This roller is set so that if it is given a slight push at the edge it tends to move up the incline plane formed by the steel piece H, and in doing so pushes against the end of the spring G and separates the platinum contacts L. This

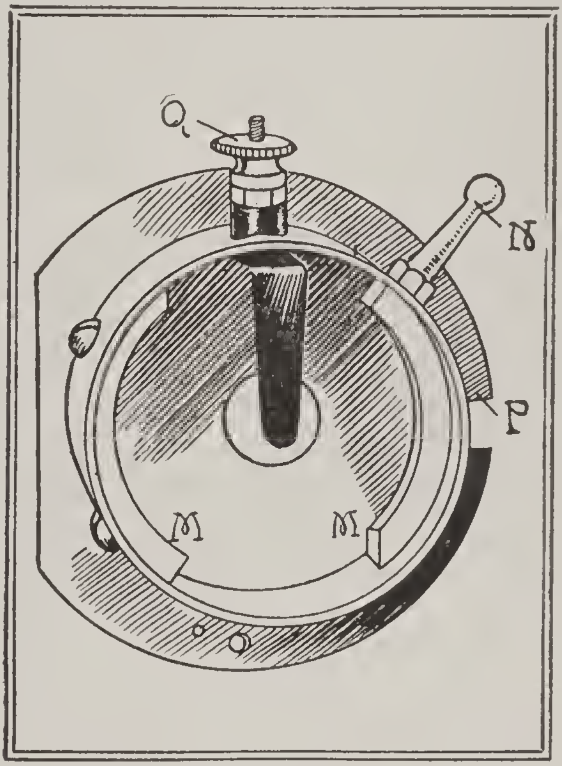


Fig. 228
Herz Magneto Advance

contact-maker revolves bodily with the armature, and in its rotation the fiber roller K strikes upon two steel projections M—Fig. 228—held in the case, thus breaking the circuit at the points of maximum induction twice in each revolution, at which time the induced current is set up in the secondary winding of the magneto.

It is scarcely necessary to comment here that

the primary and secondary windings are thoroughly insulated from each other, and that, with the making and breaking of the primary current an induced current is set up in the secondary winding, which because of the many turns of wire in this winding, is of a particularly high voltage. For cutting off the spark when desired a terminal is provided on the contact-maker case, which gives a connection by means of a spring pressing on the head of a

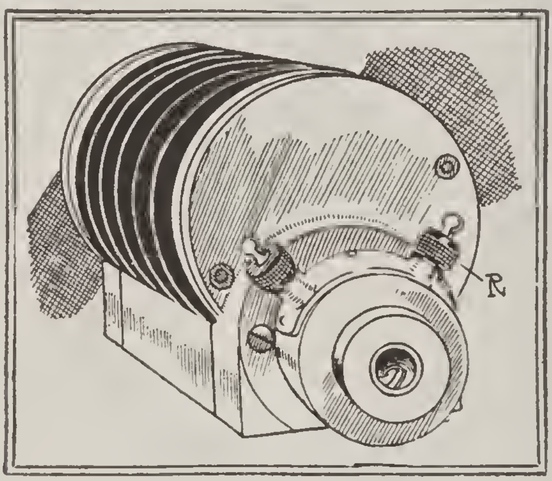


Fig. 229
High-Tension End

steel screw in connection with the insulated end of the primary winding, which thus can be short-circuited at will. In advancing or retarding the spark, connections are made with the ball-ending N, Fig. 228, the contact-maker having a 30-degree movement for this purpose. The high-tension end of the armature has mounted upon it a deeply recessed insulating collar, with a metallic sector within it. Upon this sector are small carbon brushes for draw-

ing off the high-tension current. In Fig. 229 appears a magneto suitable for a two-cylinder engine with its high-tension terminals R located at 90 degrees to each other. To obtain the two sparks the high-tension contact piece, or sector is fitted with an insulating collar, which does not go quite half way round, and thus makes alternate contact with the two carbon brushes R, sending the spark to the respective cylinder. In four-cylinders a distributer is combined. The safety spark gap is

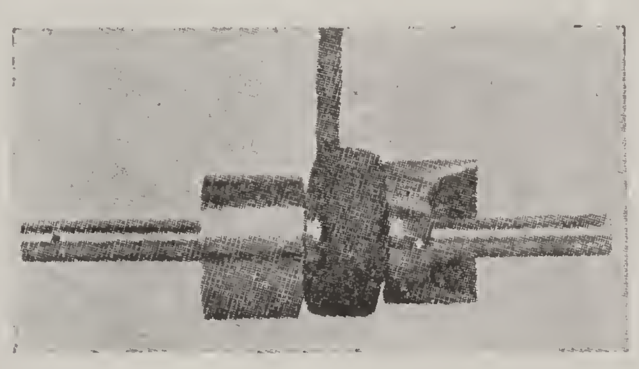


Fig. 230
Inductor Magneto Shaft

located between the high-voltage sector and the armature, and if the spark exceeds ⅜ inch it bridges the insulating collar to the armature.

High Tension Inductor Magneto. This type of magneto, now so extensively used for ignition purposes, is a comparatively recent product, the result of many years of experiment and development. The principles of its action are as follows: By revolving a solid steel shaft on which are two drop-forged steel magnet inductor wings, Fig. 230, the magnetic field is

reversed twice during each revolution, and creates two electrical current waves, or impulses per revolution. The direction of flow of the magnetic current is changed at each impulse, thereby generating an alternating current. A circular shaped stationary winding of magnet wire is imbedded between the poles of

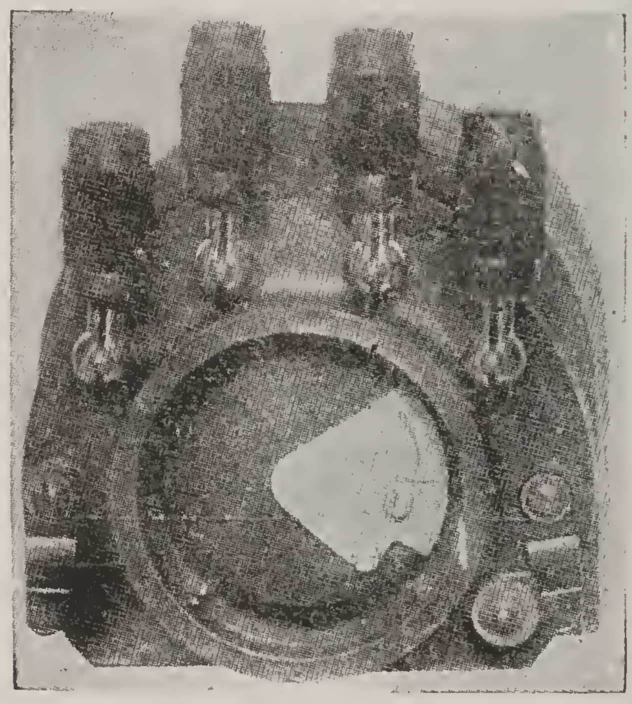


Fig. 231
Distributor for Inductor Type

the magnets and around the inductor shaft, and a strong current is generated in it and carried directly through the circuit breaking device by means of heavy lead wires, thus dispensing with the use of carbon brushes and collector rings.

There are no revolving windings nor moving contacts, and consequently many sources of

trouble are eliminated. The current is carried to the transformer coil located on the dashboard, where it is stepped up to the high voltage necessary for creating the hot jump-spark.

From the transformer the current is conducted back to a hard rubber distributer, see

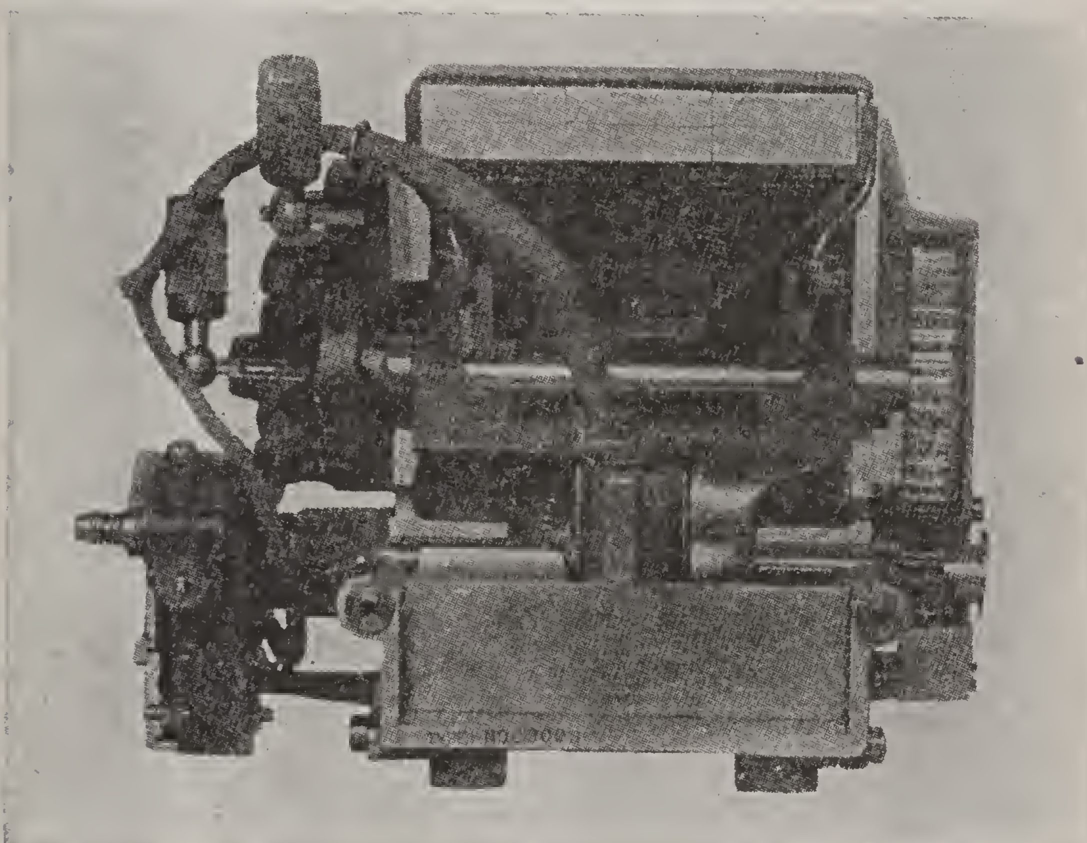


Fig. 232
Longitudinal Section Through Inductor Type of Magneto

Fig. 231, on the face of the magneto, and from thence to the spark plugs. The distributer shaft, located immediately above the inductor, revolves a metallic segment past the terminals of the wires leading to the spark plugs. The high tension current is carried to this segment, and transmitted to the spark plug. A magneto

of this type, and gear driven, gives what may properly be called perfect timing. A hot spark is delivered in the cylinder under compression at the exact instant desired.

The device is also reliable for starting the motor from the seat without cranking, for the reason that the motor always stops with the magneto in such a position that the first spark will occur in the cylinder under compression, and where batteries are used a push button is provided, which by merely touching will create the spark where needed. Fig. 232 shows a sectional view of the magneto.

How to Remove and Replace a Magneto. When about to replace or remove a magneto it is well to see that all separable parts are properly marked, and if not, mark them. This may be done with a center punch, cold chisel, letters or numerals. In Fig. 233 is shown the guide marks generally used in connection with a high-tension magneto of a four-cylinder motor. The center punch marks C, on the Oldham coupling such as is usually employed on the magneto shaft between the magneto and its driving gear, serve as a guide in replacing the magneto. All that is necessary in replacing a high-tension magneto so marked on a four-cylinder, four-cycle motor is to see that the marks are directly opposite each other; but in two or six-cylinder motors, where the crankshaft and the armature of the magneto do not run at the same speed, care must be taken either not to move the

crankshaft while the magneto is off or to check up the timing before it is replaced. In the same illustration is shown the method of marking the timing gears. These marks are made with a cold chisel and are generally present in up-to-date construction. When a new gear is fitted to a magneto, or to the crank, or camshafts for that matter, it should be marked in the same place relative to the keyway as the old

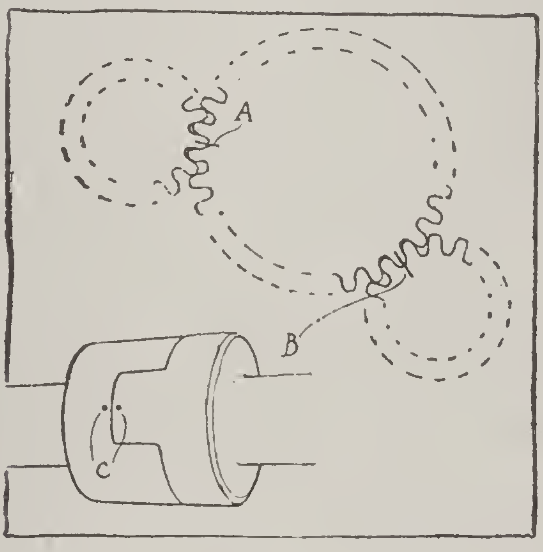


Fig. 233

gear, and both marks A and B should line up properly when the gears are in mesh.

Magnetic Clutch. The elimination of the clutch has long been a dream of automobile inventors. Many attempts also have been made to simplify, or dispense with the differential gear, another source of trouble and expense. Figs. 234, 235, 236 and 237 show views of a magnetic clutch and transmission, the efficiency and reliability of which is yet in the balance. Referring to Figs. 234 and 235 it will be noted

that the rear axle is made in one piece, so proportioned as to have the greatest section at the point of maximum bending moment, which point is the center, thus giving great strength to the whole rear construction. On the outer ends of the rear axle are keyed a pair of magnetic clutches, one at each end. Except for the diameter, which is slightly greater, these

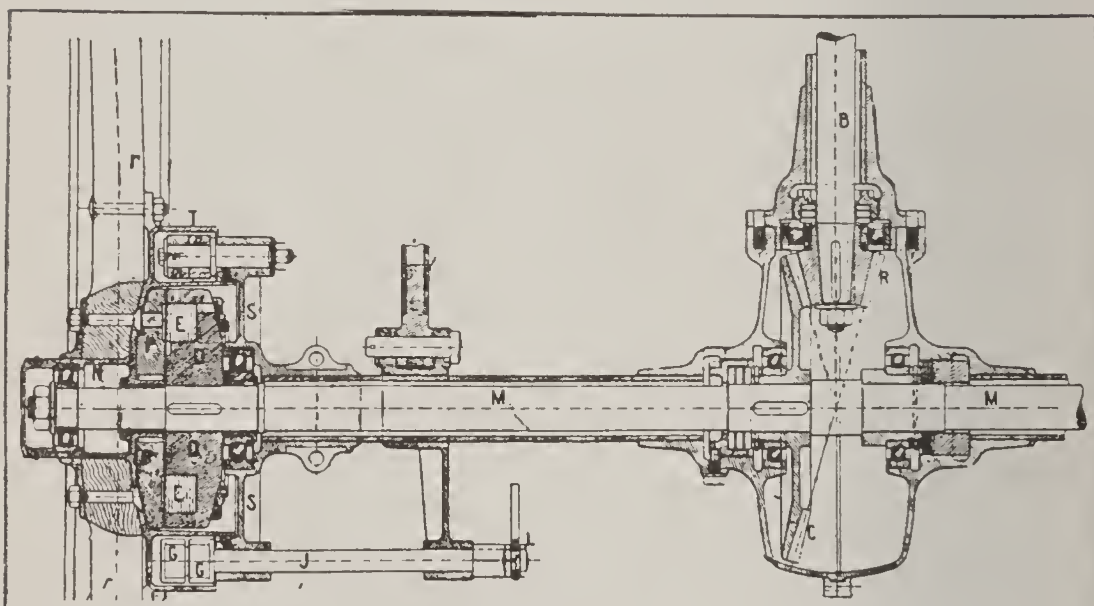


Fig. 234
The One-Piece Rear Axle Looms Up Large

are the same as the clutches used to operate the transmission gears. The action is the same also.

When current is turned into the magnet E, contained within a recess in plate D, the corresponding plate P, incorporated in the rear wheel, is attracted and, as long as the current passes and energizes the magnet, the wheel is driven by the rotating rear axle. As soon as current

is cut off the wheel is freed, and is no longer driven by the motor. This is the action which displaces the differential. The steering gear turns free up to a certain angle, at which it automatically cuts off the current to the inner wheel, which is thus disengaged, while the outer

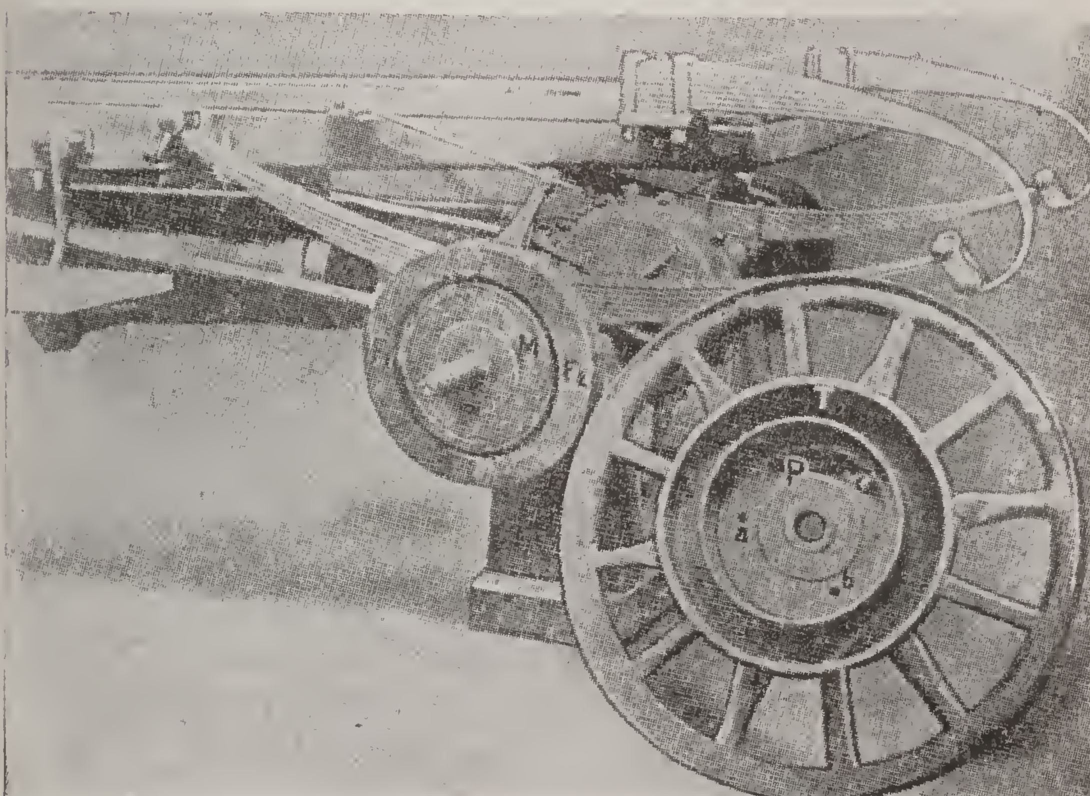


Fig. 235
View of Rear Construction, with Wheel Removed

wheel continues to drive the car, the result being a perfect differential action, all being accomplished automatically by the simple movement of the steering gear, no manual work by the driver being necessary.

The brake drums, wheels and other parts are standard as shown in Fig. 235, in which M is

the magnetic clutch, and F^1 and F^2 are the two halves of the hub brakes.

The transmission is of the individual clutch type, the clutches consisting of electro magnets.

Fig. 236 shows the arrangement, the jack-shaft being above the main shaft. Upon the latter the gears are placed which are clutched up to the shaft to obtain the different speeds. These are three in number with direct drive on

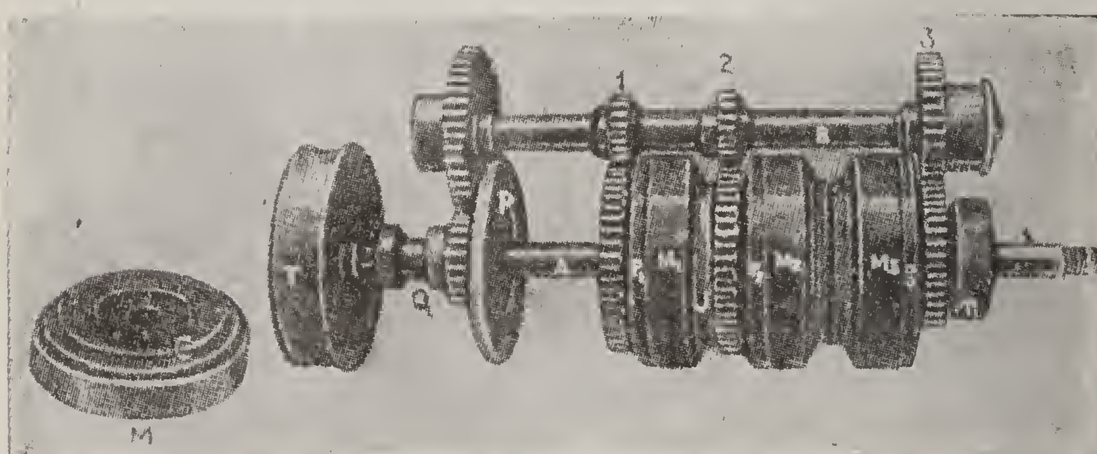


Fig. 236
Transmission Parts, Showing Clutches in Place

the high. To engage any gear, a current is impressed on the windings of the magnet, which is keyed to the shaft. This attracts the plate carrying the gear, and the desired speed is thereby obtained. There are four of these electro magnets, and four of the plates, that for the high speed being made integral with the gear itself. Fig. 237 shows the plates and other parts comprising the whole of the two clutches. M^1 is a full view of the magnetic plate, and shows the

keyways for securing it to the shaft. B is the magnet complete with a wire leading to the rings. M^2 shows the magnet set into place. These represent at the same time the gears themselves and their method of operation and, with the case, and bearings complete the transmission. Two sources of electric current are required. In addition to the ordinary ignition equipment, there is another magneto for sup-

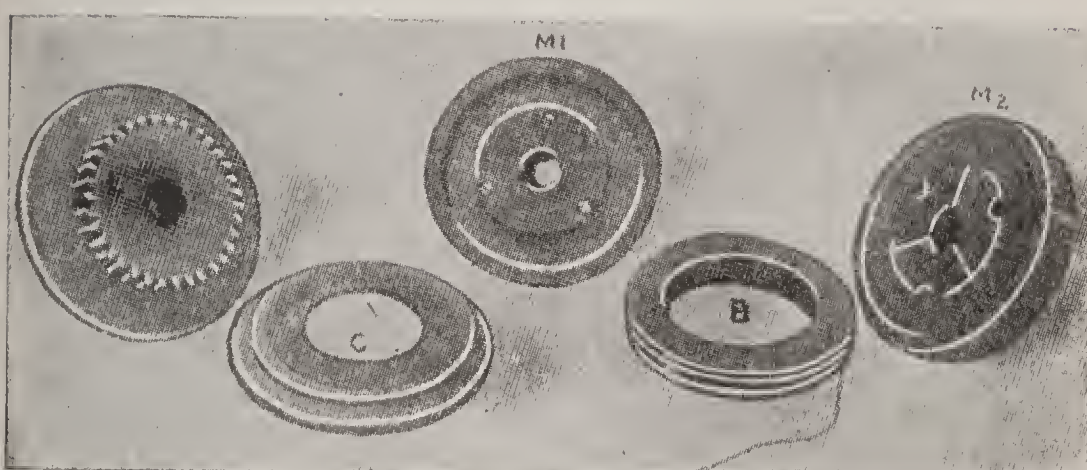


Fig. 237
How the Magnetic Clutches Look When Dissembled

plying current to the magnets. This is located upon an exténsion of the lower half of the gear box, extending from the side of the box to the main frame on the right hand side, forming a wide shelf. This magneto is enclosed in a water-tight case, and is belt driven from the cardan shaft. It is constructed with special windings to produce a current of perfect constancy but limited amperage. At very high speeds the voltage increases slightly.

The following advantages are claimed for this specially wound magneto over accumulators for this particular work: (1) less weight; (2) smaller loss of voltage; (3) less danger of short-circuits; (4) increased reliability.

Manifolds—Correct Designs for. Since the gasoline enters the intake in the liquid state, and since there is not sufficient heat available in the air that enters to assure vaporization, the greater the length of the manifold within certain limits, the greater will be the chance of vaporizing the gasoline especially after the motor is started, because some heat will pass through the walls of the manifold and be thus communicated to the entrained liquid in the mixture while in the manifold. The delivery of an equal weight of the mixture to each of the cylinders is another important point for consideration, and depends largely upon the design of the manifold, although condensation and the mechanical separation of the non-vaporized gasoline are two factors that tend also to prevent a uniform distribution of the mixture to the cylinders of the motor.

Besides length, area must be considered. If in a single-cylinder motor, the area of the manifold is one-quarter the area of the piston, and if the length is four times the stroke of the engine, it is evident that the mixture will be allowed to rest in the manifold during the period of one complete cycle in a four-cycle motor.

If the motor develops maximum power at

1,600 R. P. M. the mixture will nominally rest in the manifold for a period of time equal to,

$$t = \frac{S}{60 \times c} = \frac{1600}{60 \times 4} = 6.6$$

in which

t=ratio of time mixture will lie in manifold of a single cylinder motor.

S=angular velocity of crank shaft in R. P. M.

C=cyclic period of motor.

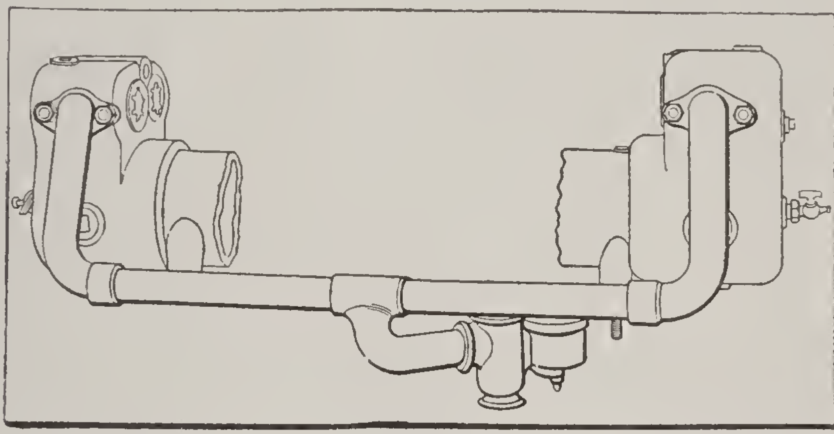


Fig. 238

In a single cylinder motor the relation of the volume of the intake in relation to piston displacement becomes an easy problem, but when the number of cylinders is increased the problem becomes more complex.

The relation of manifold area to piston displacement should be maintained, otherwise the torque of the motor may fall off as the speed increases. Fig. 238 shows a correctly designed manifold for a two-cylinder opposed motor and it will be noticed that while the intake is long

and slender, the connections to the cylinders are made in such a way as to cause an equal distribution of the mixture.

Fig. 239 shows a manifold for a four-cylinder motor, designed in such a way as to distribute the mixture to the respective cylinders with the least change in direction of flow and at the same time have all the cylinders at the same distance from the carbureter, as nearly as pos-

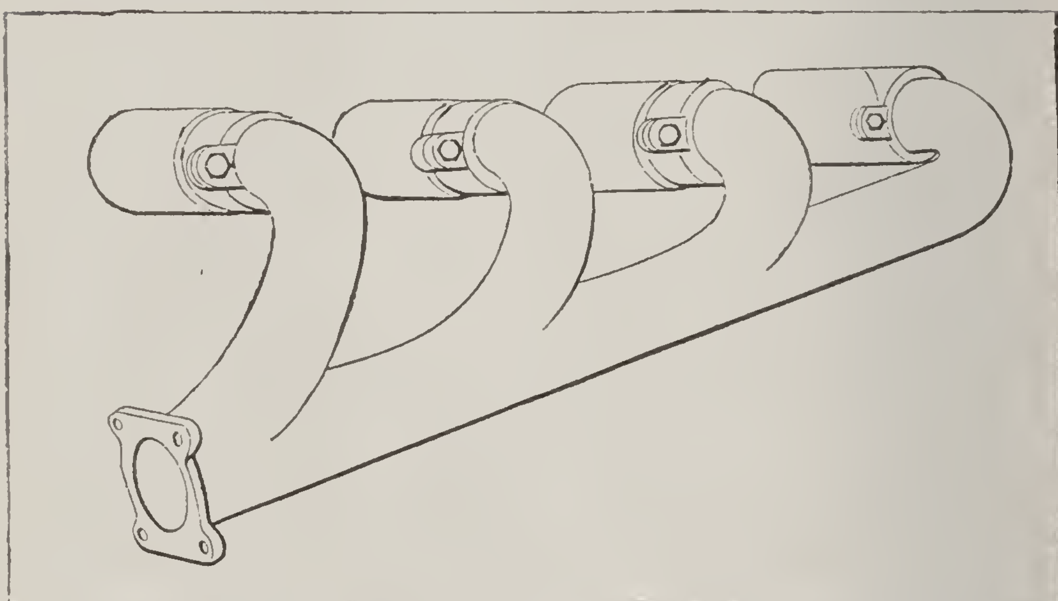


Fig. 239

sible. In the case of siamesed cylinders the same results may be arrived at by using a manifold similar to the one shown in Fig. 240, in which the carbureter is well below the valves of the motor, and the Y with long, easy bends branches from the riser at a low point.

Another design is shown in Fig. 241, involving a Y-shaped manifold with a casting of a box-like character, possessing no dividing walls

excepting those which separate the mixture from the exhaust gases that enter a cored portion of the casting, near the cylinders, high up, for the purpose of aiding in the process of evaporation. In view of the large amount of gas that can be stored in the space afforded it is likely that benefits follow its use, although, in the absence of exhaust heat, the space might be regarded as excessive.

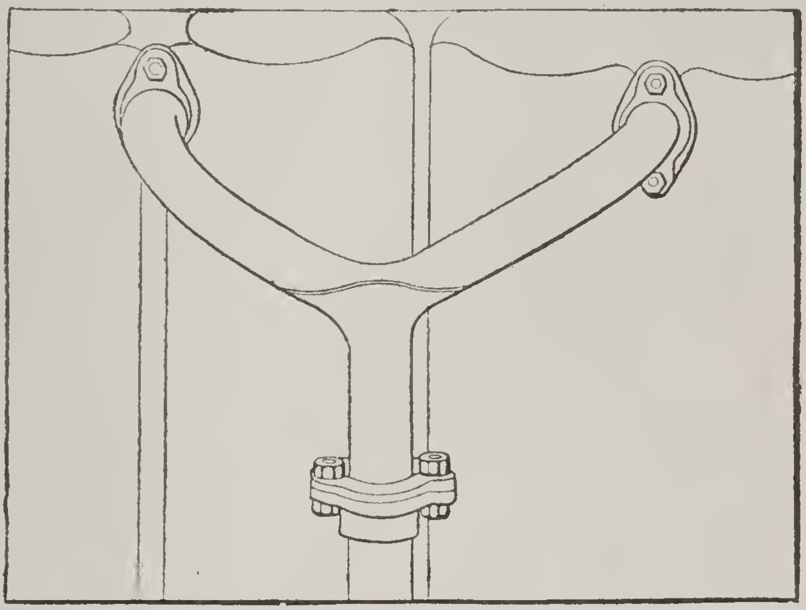


Fig. 240

Fig. 242 shows a manifold in which the enlargement is above the riser, although a part of it. This manifold is used on four-cylinder motors, but does not afford as large an area for the transfer of heat, which is really not a necessity, provided the carbureter is so designed that it will properly vaporize the mixture, and free it from entrained liquid.

The manifold shown in Fig. 243 for a four-cylinder motor is but a development of the Y

shown in Fig. 240, possessing the advantage of no change in direction of flow of the mixture to the different cylinders. Another commendable feature in this type of manifold is its neat appearance, but when this plan is applied to a six-cylinder engine, as shown in Fig 244, certain complications arise, not the least of which is that the gas is compelled to go in a reverse direction in order to get to cylinders 3 and 4. Also the distances to cylinders 1 and 6 are con-

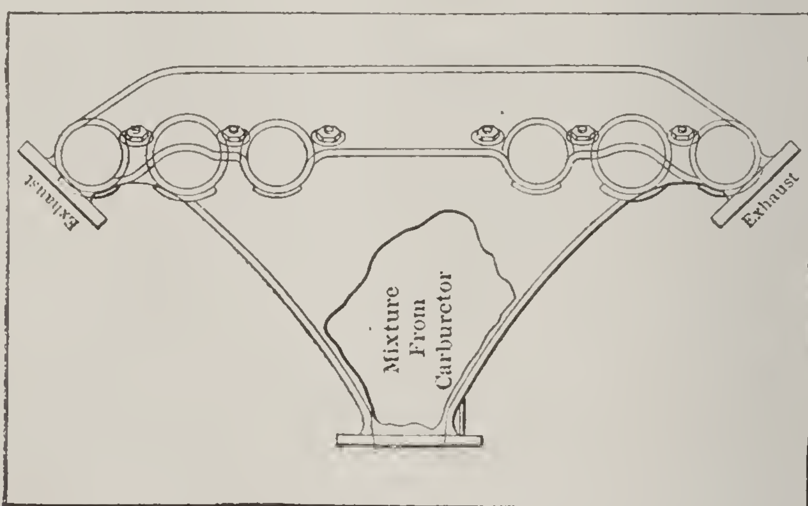


Fig. 241

siderably increased. These, with other faults in the design will no doubt tend to lessen its efficiency when applied to a six-cylinder unit.

Fig. 245 presents a view of a manifold for a six-cylinder engine, in which an attempt is made to equalize the pressures of the gas streams in their passage to the cylinders. Although the flow is not in one common direction, still the distribution is much better than that attained in Fig. 244, and the area of surface afforded

for the transfer of heat is also much larger. The manifold shown in Fig. 246 is designed with a view to the balancing of the forces due to so-called "inertia" of the gas, and it will be

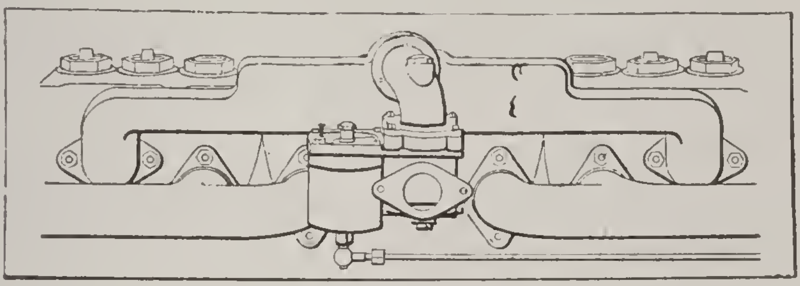


Fig. 242

noticed that the branches leading to the respective cylinders are connected in such a way as to offer equal resistance in all directions to the passage of the gases. This manifold, it is said, gives good service in actual practice.

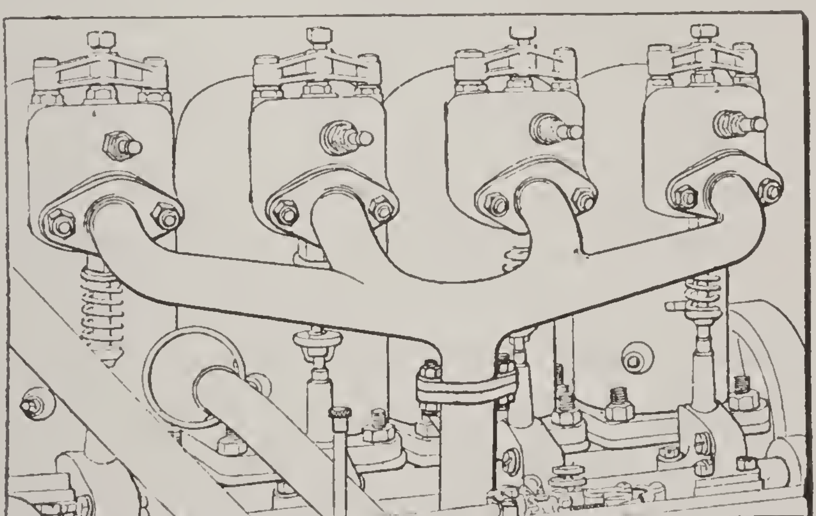


Fig. 243

Marking Car Parts. Taking mechanisms apart for repairs is very often one of the most troublesome jobs at which a repairman can be put. Between corrosion, dirt, and distortion, and

perhaps fractures, it generally is the most disagreeable work of the shop. Often, too, the mechanism to be taken apart and repaired is one with which the repairman has no acqaintance; hence, he must feel his way, so to speak, or after it is taken apart he may find that putting it together again is like solving an intricate puzzle. Before commencing to take any mechanism apart it should be thoroughly looked over in order to gain a clear idea of the general

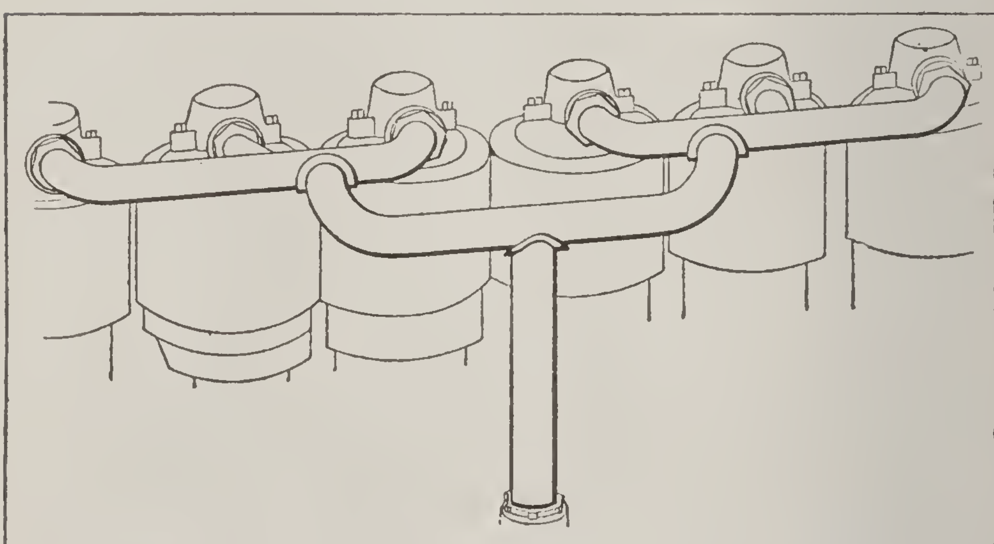


Fig. 244

arrangement and location of parts. In most cases it will be necessary to mark similar parts by stamping, or with a center punch. It is customary among most manufacturers to stamp with letters or figures all adjoining parts which are individually fitted, such as connecting-rods, pistons, brasses and their blocks and caps, valves, push-rods, guides, gears, etc. Nevertheless, care should be taken to see that all parts are

properly marked, and to mark those which are not. A large number of similar parts can be marked with center-pops, not only by increasing the number of pops, but also by arranging them in devices, as shown in Fig. 247. The marks should not be put on working, or machined occlusal surfaces, but upon places where there is no direct contact.

Motors—Two and Three Port. In the two-port motor, as illustrated in Fig. 248, the functions are as follows:

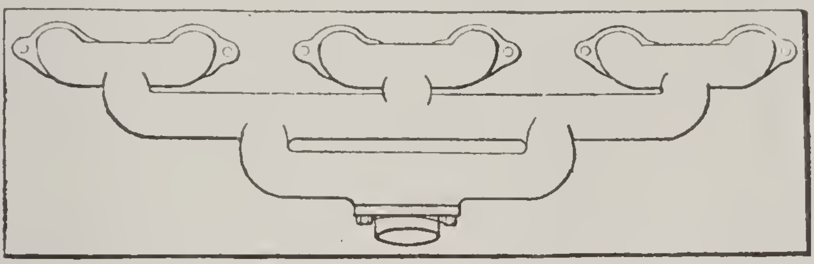


Fig. 245

The first stroke of the piston produces a vacuum in the crankcase and the mixture rushes in (as a consequence) through the check valve in the motor case. The second stroke compresses the mixture, and when the communicating port is uncovered the mixture surges into the cylinder. The next (third) stroke compresses the mixture entrapped in the cylinder, since the ports are then covered by the piston, and at the proper instant the mixture is ignited.

From this point on it is a normal repetition of functions, and once the motor gets under way it two cycles. The three-port motor, Fig. 249, differs in that the mixture is taken in

through a third port uncovered by the piston, instead of through a check valve in the case, and the details in practice change accordingly.

Needle Valve. Valves with cone-points, and having a fine thread on the stem are known as needle-valves and are used for the regulation of

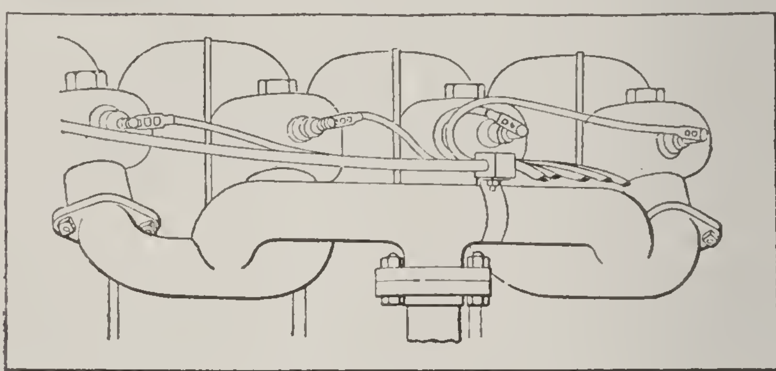


Fig. 246

the supply of gasoline to the carbureter or mixing valve of a motor.

Non-Freezing Mixtures for Radiators. In cold weather, the circulating water, the oil, and the carbureter require special attention. If the car is to be run regularly during

Fig. 247
Marking Designs

the winter, it is advisable to use a non-freezing mixture in the water-jacket. If the car is not to be used regularly, it may not be necessary to employ such a mixture, but in that case great care is necessary to prevent the water from freezing unexpectedly. If the car

is kept in a barn, the water should be drawn off completely after the car has been used, and the drainage cock should be so located and the piping so arranged that there are no water pockets in which the water may freeze and ob-

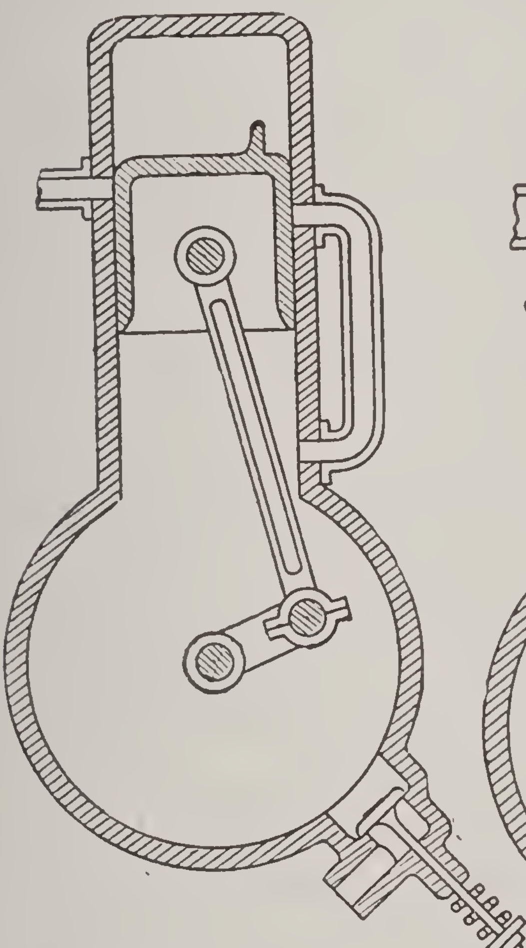


Fig. 248
Two-port Motor

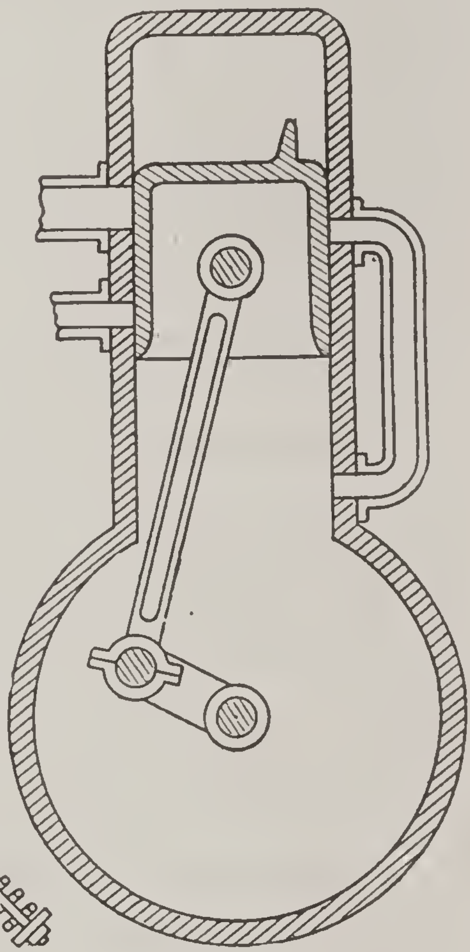


Fig. 249
Three-port Motor

struct the circulation. If the water freezes in the pump, the latter is likely to be broken when the car is started the next morning. If water freezes in the water-jackets, it will burst the jackets unless they are made of copper. When the car is left standing for an hour or so, cloths

or lap robes may be thrown over the radiator to check the cooling: this is cheaper and safer than leaving the motor running.

The two substances most used to prevent freezing are glycerine and calcium chloride. A 30-per-cent solution of glycerine in water freezes at 21° F.; and a solution of one part of glycerine to two parts of water is safe from freezing at 10° or 15° F.; 40-per-cent solution freezes at zero. A small amount of slaked lime should be added to neutralize any acidity in the solution. Glycerine has the objection that it destroys rubber, and the solution fouls rather quickly.

A cheaper mixture, and one preferable where the temperatures encountered are likely to be below 15° or 20° F., is a solution of calcium chloride. This must be carefully distinguished from chloride of lime (bleaching powder), which is injurious to metal surfaces. Calcium chloride costs about 8 cents a pound in bulk, and does not materially affect metals except zinc. A saturated solution is first made by adding about 15 pounds of the chloride to 1 gallon of water, making a total of about 2 gallons. Some undissolved crystals should remain at the bottom as evidence that the solution is saturated. To this solution is added from 2 to 3 gallons of water, the former making what is called a 50-per-cent. solution. A little lime is added to neutralize acidity. A 50-per-cent solution freezes at —15° F.

Whether glycerine or calcium chloride is used, loss by evaporation should be made up by adding pure water, and loss through leakage by adding fresh solution. In using the chloride, it is important to prevent the solution from approaching the point of saturation, as the chloride will then crystallize out and clog the radiator, besides boiling, and failing to cool the motor. A 50-per-cent. solution has a specific gravity of 1.21, and should be tested occasionally by means of a storage-battery hydrometer. Equally important is it to prevent the water from approaching the boiling point, whatever the density, as boiling liberates free hydrochloric acid, which at once attacks the metal of the radiator and cylinders.

A solution of two parts of glycerine, one part of water, and one part of wood alcohol has been recommended, which is said to withstand about zero temperature.

Certain mineral oils used for the lubrication of refrigerating machinery are recommended for cooling, because they remain liquid at very low temperatures. They are not particularly good heat conductors, however, and will not keep the motor as cool as the water solution. If the oil is used, it must be cleaned from the radiator by the use of kerosene and oil soap, before water can again be used effectively.

As regards lubrication, the principal danger is that the oil will thicken from the cold so that it will refuse to feed. This is avoided by using

cold test oil, which remains liquid at lower temperatures than ordinary oil, or by adding to the ordinary oil some kerosene or gasoline, and increasing the feed. If the oil tank is located close to the engine, it will remain liquid, even in quite cold weather. But unless the car has been kept in a warm place over night, the bearings are liable to run dry before the car has warmed up.

Effect of Cold on Gasoline. The temperature has a very marked effect on the rapidity with which gasoline vaporizes, and in cold weather it is necessary to supply heat to the carbureter.

The carbureter should preferably be jacketed, and it may be warmed either from the circulating water, or by taking a small quantity of the hot gases from the exhaust pipe. If water is used it should be taken from a point just beyond the discharge of the pump, and should be delivered to the return pipe from the engine jacket to the radiator.

Whether exhaust gases or water is used, the flow should be regulated by a cock, otherwise too much heat will be received in warm weather. When the carbureter is cold, the engine may be started by pouring warm water over it, care being taken not to let any portion of the water get into the gasoline through any aperture in the top. Another method of warming up the carbureter is to wring cloths out of hot water, and wrap them around it.

Fire for warming the carbureter or any other part of the motor should never be used.

Oil and Gasoline Testing. In selecting gasoline for any use, it is usually sufficient to know its density by Baumé's scale, this being the rating at which it is sold in the general market. For instance, "Gasoline 72 Baumé" means that the density of the gasoline is 72° of Baumé's hydrometer. Kerosene is generally rated by its flashing point. This point is the number of degrees of temperature to which it must be heated before the vapors given off from the surface of the oil will take fire from a flame held over the containing vessel. Thus, oil of 150° test is oil that will flash or take fire when heated to a temperature of 150° F. Kerosene, at ordinary temperatures, should extinguish a lighted taper when the taper is plunged into it.

Oil for Cooling. Oil can be used most efficiently to cool a motor in summer time, this having been conclusively proven in continuous tests in which oil was circulated through the water system at the same speed as water, and the motor gave considerably improved results. In recent experiments, although there was no trouble cooling water to the thermo-capacity of the radiator, yet when oil was passed through instead of water there was great disparity of results. One type of radiator, which cooled effectively with water, gave poor results when oil was used; in fact, the radiator giving the poorest results with oil gave best with water.

and vice versa. From this it is evident that conditions must be altered when a change is contemplated from water to oil for cooling work. In one particular test it was found with a temperature drop of 12 degrees with oil, the radiator gave a cooling effect of 700 cubic units, but when water was used, only 70 per cent as much heat was radiated, in spite of the fact that the air circulation was increased. In these experiments the radiators used were standard makes and designed for water use. These several tests, made by H. B. MacFarland, professor of applied mechanics and thermo-dynamics at Armour Institute, Chicago, indicated that the best radiators, when using oil, are 50 per cent more efficient than when using water. The experiments also proved that the engine was more efficient because it was possible to use the oil at a much higher temperature in the jacket without boiling than the water could be used at. The oil used in these tests was a very common grade of machinery oil bought at 12 cents a gallon.

Oil Gun a Valuable Adjunct. A handy appliance for the garage and even for the private owner is a large quick action oil gun, which is easily made from an old bicycle pump by plugging up the outlet and drilling and tapping the bottom plate for a nozzle. The bottom plate can be cut down to the diameter of the pump barrel in case it has an extension to be held by the foot when pumping. Autoists will find such

an oil gun as the above handy in many ways, as for quick filling of lubricators and scattered oil cups. It is very convenient also for sucking out the oil from the gearcase when a fresh supply is to be put in. This oil is usually too stiff to drain out, and as it is too full of steel chips to be allowed to stay in the gearcase, it must be removed in some manner. Obviously for such

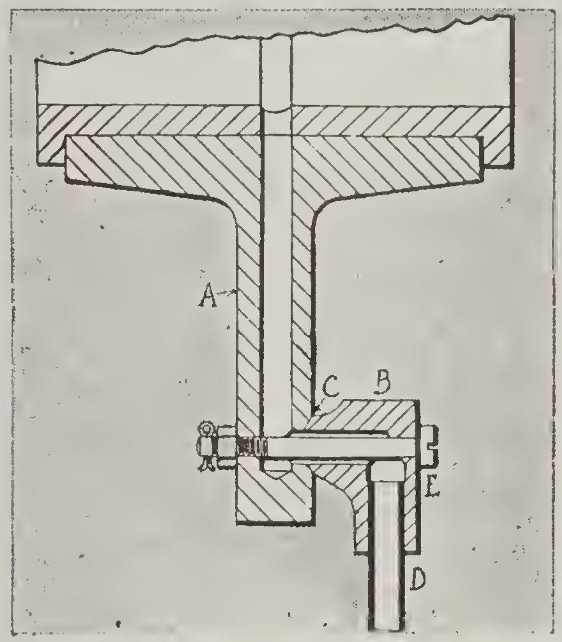


Fig. 250

use the nozzle of the oil gun should be short and fairly large to permit the thick oil to enter.

Oil Pipe Connection. The ordinary pipe fittings are not always reliable for oil and gasoline pipes subject to vibration, and where the failure of a connection would involve serious consequences, as in racing engines, a better form of connection is desirable. Fig. 250 shows a special form of union devised by Crane &

Whitman, of Bayonne, N. J., for important oil pipes. It is shown in service carrying oil to the under side of a main shaft bearing. The bottom cap A of the bearing is deeply ribbed and the oil duct is drilled in the rib. The connection itself takes the form of an L-shaped steel union B, having a ground seat at C and brazed to the oil pipe at D. A special screw E passes through the union, and is threaded into the further side of the rib. The oil goes around the screw, and a lock nut and cotter pin insure against coming loose under even the most strenuous conditions of service.

Should an oiler reservoir begin leaking where one of the oil leads attach to it, the only suitable solution is the immediate soldering of it. The use of adhesive tape will sometimes suffice for a time, but the vibration generally renders it a poor repair. A small soldering iron is a most valuable part of a repair kit, and with it a soldering repair can be made in less than 20 minutes. Oilers have been taken off, a fire built by the roadside and the soldering done in less than 15 minutes, but the amateur who has not been accustomed to handling a soldering iron can hardly expect to do as expeditious a job as this, for, though a simple tool, considerable knack is required.

Offset Crank Shafts. The practice of offsetting the crankshaft in automobile motors is rapidly gaining converts, and there are numerous examples of offsetting to be seen at the

present time. In this scheme, it will be remembered, the crankshaft is not set in the plane of the middle of the cylinders. In other words, the crankshaft is set slightly to one side. The exact amount of this offset seems to be variable

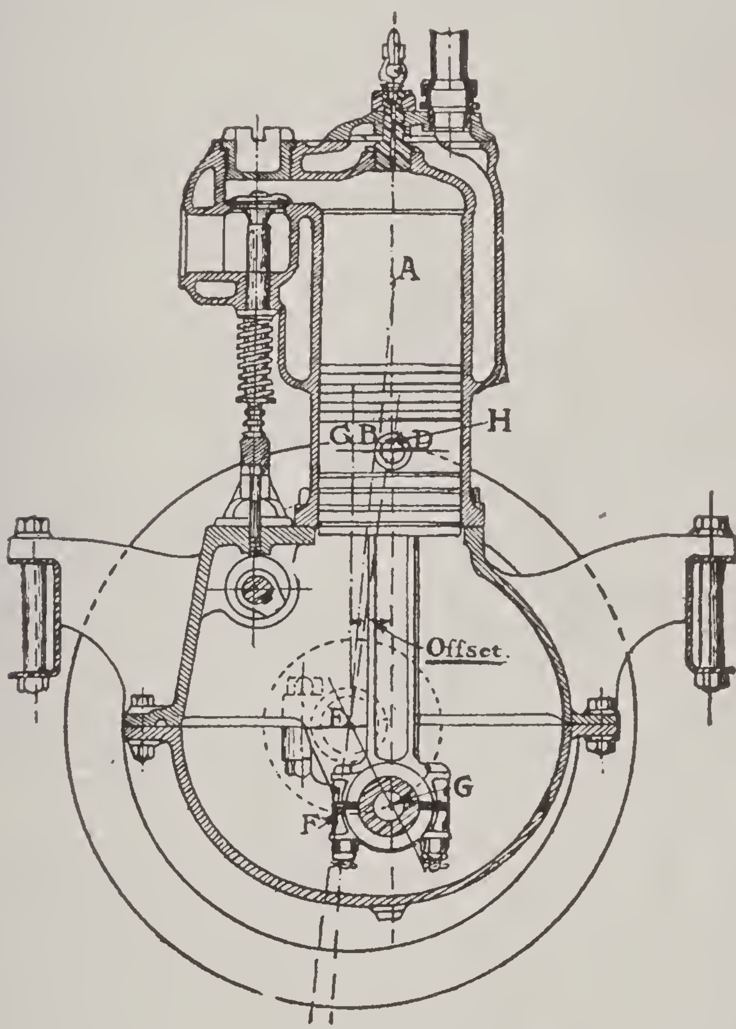


Fig. 251
Section Through Engine with Offset Crank

with different designers, but the object is always the same. When the piston is in the position of maximum compression involving the ignition and flame propagation, it is the idea to have the connecting rod in the vertical po-

sition. The force of the explosion will then come on the connecting rod endwise and the piston will not be pressed unduly against the cylinder walls.

Offset Crank Shaft Engine—Timing the Valves. To time the valves of an engine having an offset crankshaft, the inclination of the axis of the connecting rod must be taken into account. As Figure 251 shows, the connecting rod is vertical, and if the shaft center were not

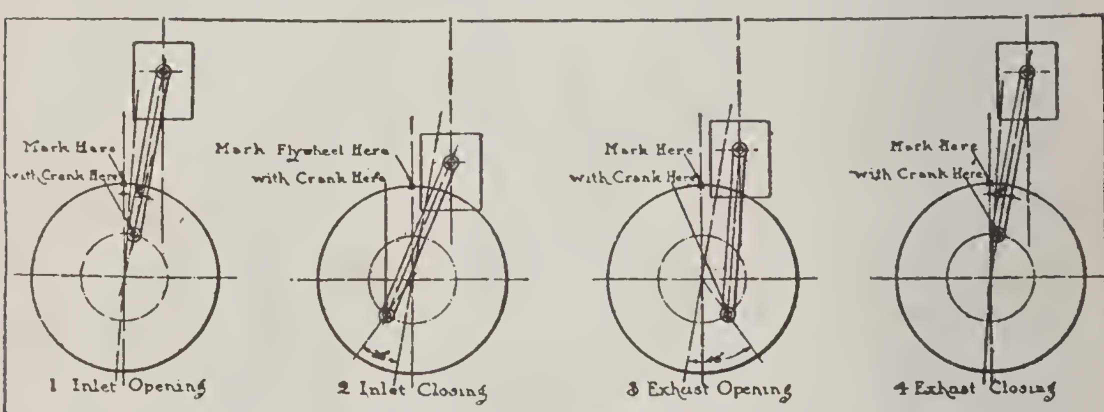


Fig. 252
Diagrams Showing the Four Positions of the Offset Crankshaft

to one side, the flywheel would be marked at the exact center of the upper face, namely, at C. In the case where the center is set over, the rod, when in a vertical position as at G is not at the end of the stroke. If the flywheel were marked at C it would not indicate correctly the lower dead center. This does not appear until the three centers, piston pin, crank pin, and crankshaft are in line, as shown by the line D E F. The flywheel should be marked at this

point, and the mark may be on a vertical line through the crankshaft center or on a diagonal as the line just indicated. In the latter instance, the mark for the lower center would be at H.

Similarly, the upper dead center, if marked, would be at a vertical point above the shaft center as C, but would assume a different position, located on a diagonal, as at A, on the center line A B E.

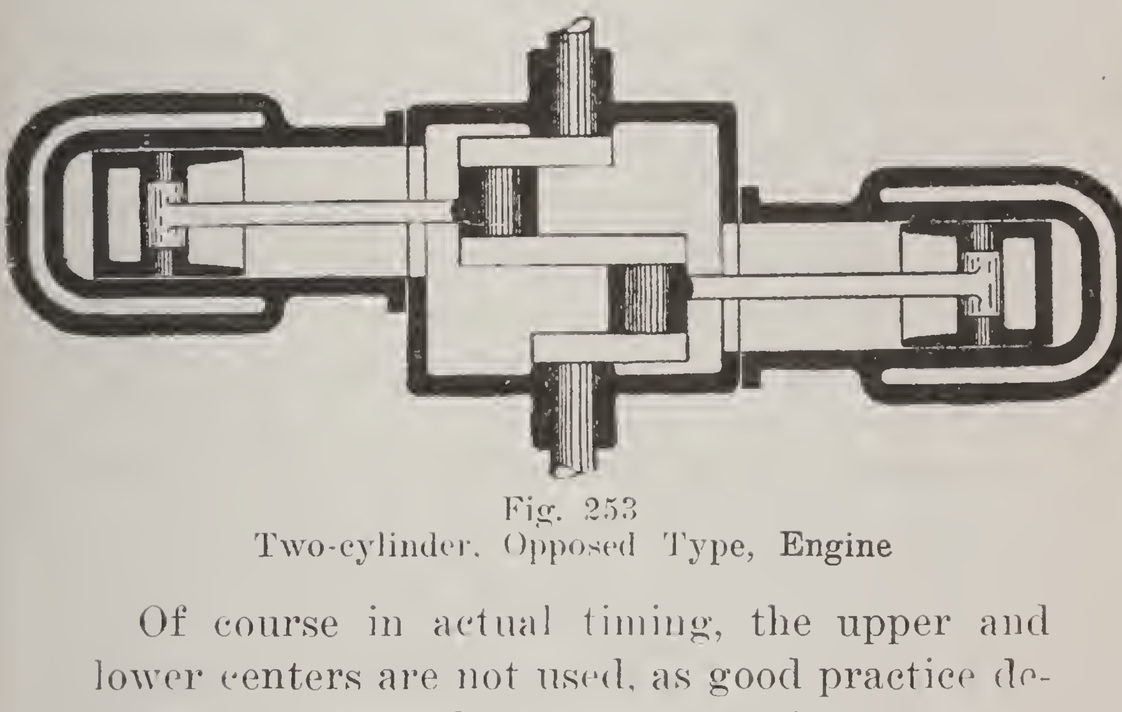


Fig. 253
Two-cylinder, Opposed Type, Engine

Of course in actual timing, the upper and lower centers are not used, as good practice decrees an overlap for the valve action, but they have been used as an illustration in this case because their use simplifies the matter.

In Figure 252, the actual marking of a flywheel is shown for a complete cycle. In this the angles selected follow the best modern practice, being as follows: Inlet opens at 8 degrees past the upper center, and closes at 26 past the

lower center, giving an inlet opening, total, of 198 degrees. Exhaust opens at 46 degrees before the lower center and closes at 5 past the upper. This gives the whole angle for the exhaust, 231 degrees on the crankshaft.

As shown, the markings are put on the flywheel directly above the center of the crankshaft, but the offset is taken into account.

Opposed Cylinder Motor. The two cylinders, Fig. 253, are in the same plane with their open ends joined to a common crank case. As the two cranks are upon opposite sides of the crankshaft, the two pistons are always moving in the same directions.

The outward strokes are either compression or exhaust strokes, and the inward strokes are either suction or power strokes. Thus, during one-half turn of the crank-shaft, one cylinder will be compressing while the other is exhausting. During the next, the first cylinder will be firing, and the second will be drawing its charge. During the third half turn the first cylinder will be exhausting and the second will be compressing, and during the fourth the first cylinder will draw its charge while the second is firing. It must be apparent that the two cylinders fire at periods one revolution apart, and upon the half revolutions when neither cylinder is firing, one of them is compressing. Thus, there is a power impulse in every revolution, and the action of the engine is shown in Fig. 254. A flywheel of less weight is required to

overcome the idle stroke than is found necessary in the single type to supply energy when no power is being developed. The moving parts are balanced and the explosion reactions alternate in that direction.

The two-cylinder opposed motor is one of the best forms of two-cylinder motor, and is used extensively for motors up to about 16 horsepower. Since the cylinders are set end to end, with the crank case between them, the combination is naturally rather long, and it is not

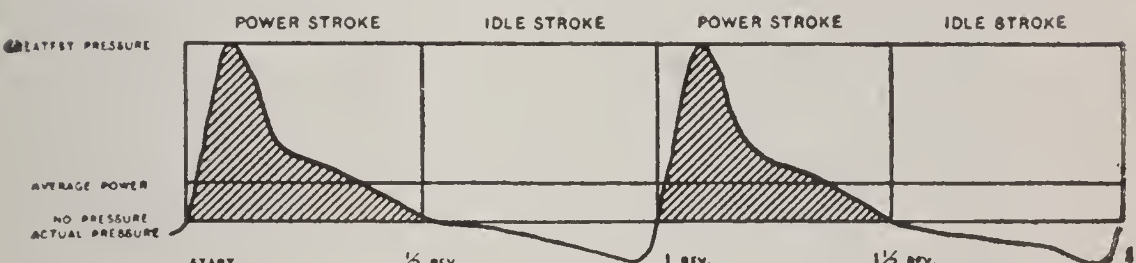


Fig. 254
Power Furnished by a Two-cylinder Engine

practicable to employ this type of motor in anything but the horizontal position.

Overheating—Causes of. Overheating of the engine, when not traced to poor circulation, is almost always caused by too much gasoline. There are, however, many possible causes of over rich mixture, some of which on the face of them might seem to be causes of lean mixture rather than rich. Prominent among these latter is too low a gasoline level in the float chamber due to the float valve closing too soon. The immediate effect of this is to make the mixture too lean at starting, and at low

speeds. Starting is therefore difficult, and if the auxiliary air valve begins to open at the usual motor speed, the mixture will again be much too lean. These symptoms, however, unless properly interpreted will probably lead the owner to increase the gasoline supply, or to adjust the spring tension of the auxiliary valve so that the latter will not open until quite high speed is attained. In other words, he adjusts to give a suitable mixture at one speed, and at other speeds the mixture is extravagantly over rich. It is well not to be too easily satisfied with the carbureter's performance, as it may be found that one fault such as the above has been imperfectly offset by another fault in the other direction instead of the correct adjustment being made where the fault really lies. A good carbureter will give a sensibly correct mixture at all speeds within the ordinary range of the engine. If it fails to do this the thing to do is to investigate until the trouble is found.

Insufficient lubrication increases the friction between the piston and cylinder, and so generates extra heat. Bad or unsuitable oil may have the same effect.

Wear of the cams, tappets and valve stems may be the cause of overheating, as it would not require much loss from the faces of the various moving parts that come in contact to cause a more or less appreciable difference in the operation of the valves, and as this wear tends to bring about a later action, it may be

sufficient in the case of the exhaust valve to retain the burnt charge considerably beyond the time at which it should be allowed to escape. Where a motor runs at a speed of 800 revolutions per minute or over, it will be evident that it is a matter of very small fractions of a second.

Another cause of overheating may be the deposit of a fine film of scale on the inside of the circulating pipes and radiator. This scale is of a mineral nature, and, in addition to being an excellent nonconductor of heat, it is deposited in such intimate contact with the metal that the latter is practically insulated and its radiating power entirely lost.

OVERHEATING—EFFECTS OF. The immediate effect of overheating is to burn up the oil in the cylinders, or crank case. This causes a smell of burning, and an ordor of hot metal. There is sometimes a slight smoke and the motor will make a knocking sound. The cooling water begins to steam, and the car will gradually slow down and finally stop.

The most serious cause of a stoppage on the road is overheating, which causes the lubricating oil to burn up and the piston to expand and grip or seize in the cylinder.

OVERHEATING—REMEDIES FOR. As soon as any of the above symptoms are noticed:

The motor should be stopped at once.

Kerosene should be copiously injected into

the cylinders and the motor turned by hand to free the piston-rings.

The parts should then be allowed to cool.

Do not pour cold water on the cylinder jackets, for fear of cracking them, but pour the water into the tank so as to warm the water before it reaches the cylinder jackets.

A simple test in the case of an overheated motor is to let a few drops of water fall on the head of the cylinder. If it sizzles for a few moments the overheating is not bad, but if the water at once turns into steam, the case is serious.

Detach the spark plug or plugs, and turn the starting-crank slowly. This draws in cold air and cools the inside of the cylinder and the piston.

Packing. Packing or material for making gas, or water-tight joints is of various kinds. Asbestos packing comes in sheets, called asbestos paper or board, in the form of woven cloth, and also as string or rope. Rubber packing is made in sheets, either plain or with alternate layers of canvas and rubber. Some forms of packing are known as Rubberestos, and Vulcabestos, and are made of asbestos, impregnated with rubber and afterwards vulcanized.

Paper Shims. Paper is a poor material for shims of any sort where pressures are high and intermittent, as in the bearings of the engine or gearcase, under the crankcase feet, or between the gearcase and the frame. The principal

excuse for using them is that they are so handy. On the other hand, they are liable to break and disintegrate from the pressure and vibration, and it is not always easy to squeeze them up tight enough in the first place to insure their staying where they are put. If they must be used they should be thoroughly saturated with shellac, and squeezed in place before the shellac dries. The shellac will act as a finger, and will also help the shims to cling.

Parts, Extra. The necessity for carrying extra parts upon a car becomes more apparent when a breakdown occurs miles away from home, and no material at hand to repair the break with. The accompanying list gives some of the parts generally needed in time of trouble: Bolts and nuts, chain links, dry batteries, extra valves, inner tube, insulated wire, packing, spark plugs, split pins, sticky tape, valve springs, washers.

Pierce-Arrow Six-Cylinder Motor Car. Fig. 254a shows an open view of a Pierce-Arrow six-cylinder motor with chassis complete and ready to receive the body. The motor is composed of three twin cylinder units, and the crankshaft is of the seven bearing type, having journals of liberal diameter and length. Nickel steel, specially hard treated is employed in the shape of a one-piece forging, machined all over, and accurately balanced and ground to a finish within the closest practical limit. This motor is carried on drop forged steel arms attached to the

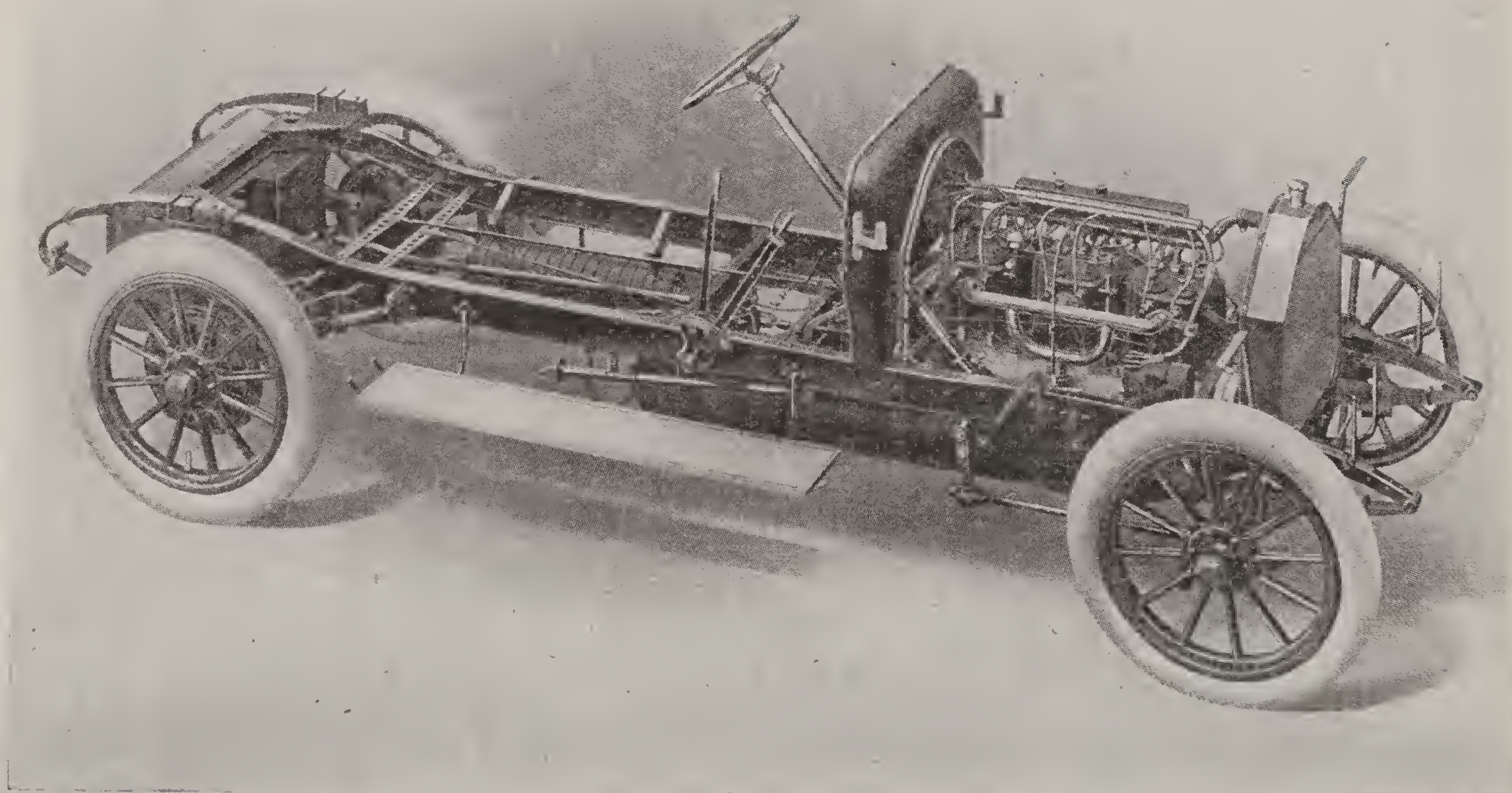


Fig. 254a
Standard Six-cylinder, 48 Horse-power Pierce-Arrow Chassis Complete. Ready to Receive the Body

aluminum crankcase by long through bolts. At their ends these steel arms are bolted directly to the pressed steel frame. The makers claim that there has never been a single instance

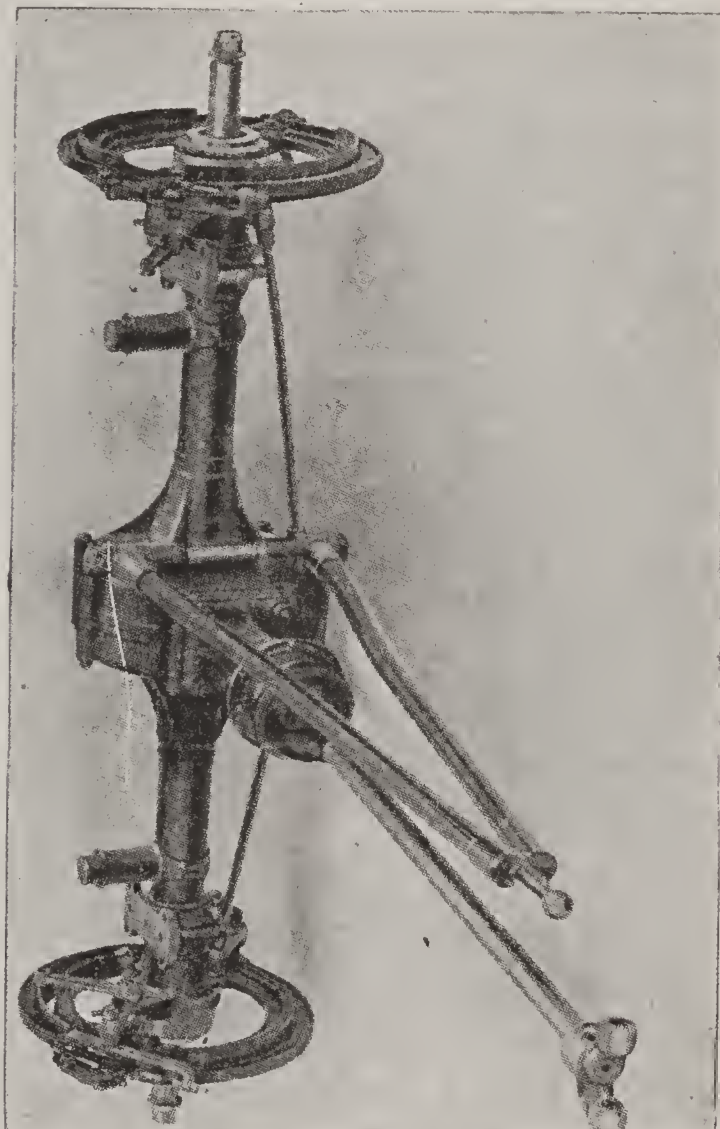


Fig. 254b
Rear Axle Unit, Pierce-Arrow Six-cylinder Auto

of failure in this construction, which certainly speaks well for its durability. Fig. 254b shows the rear axle, and connection between the clutch and gear set. In this connection two universal joints are used, in order to guard

against any possibility of distortion, or departure from a true alignment. The gear set is encased in an aluminum housing, supported on pressed steel cross members which are riveted

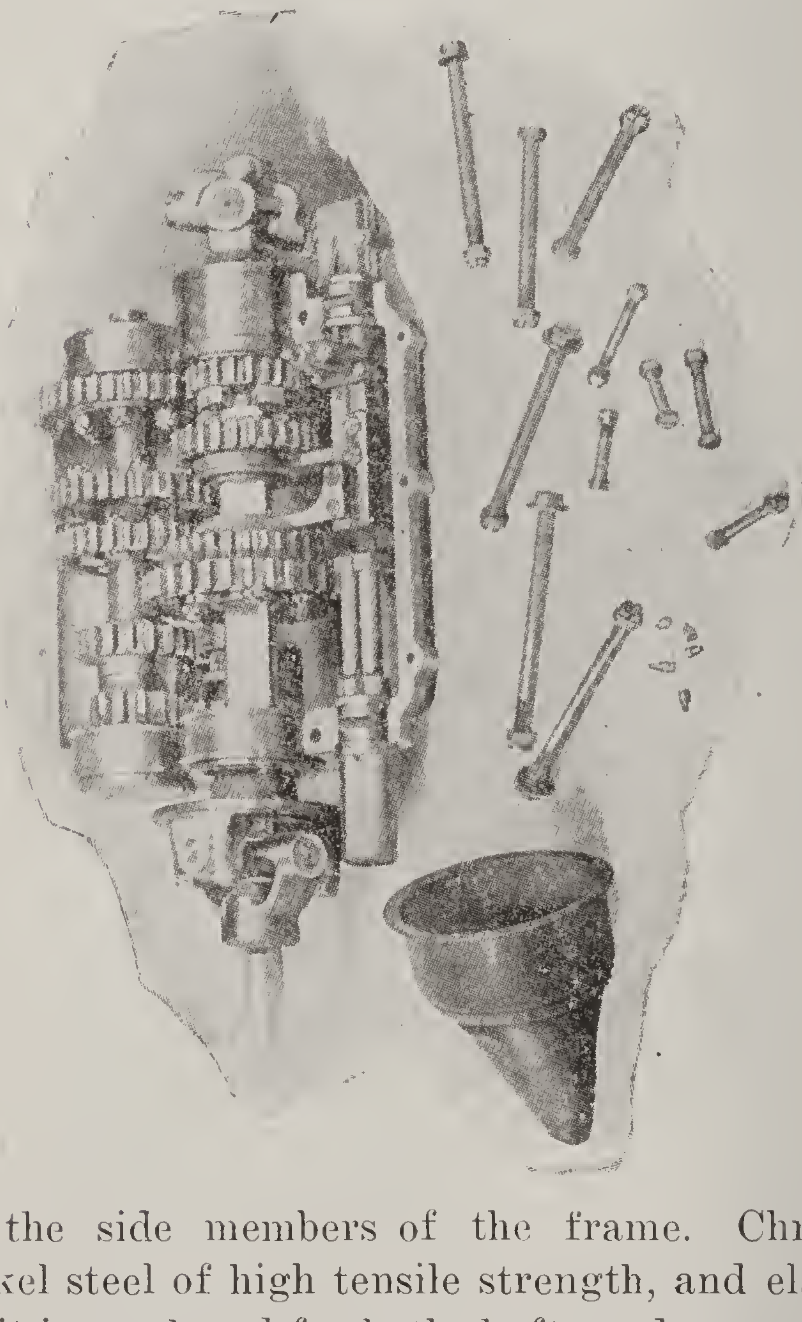


Fig. 254c
Gear Set—Pierce-Arrow Six-cylinder Auto

to the side members of the frame. Chrome nickel steel of high tensile strength, and elastic limit is employed for both shafts and gears. The moving members are splined on the main shaft, while the corresponding pinions are bolted to

flanges on the countershaft. The shafts are carried on Hess-Bright angular ball bearings of ample size to withstand the service. Speed control is on the selective plan with the H-gate and side lever, the system being distinguished for simplicity, and certainty of action. As a preventive of unauthorized tampering, the gears cannot be meshed without disengaging the clutch. The positions of engagement and disengagement are determined by spring actuated steel balls, seating in recesses in the shifting bars.

Ignition. Dual ignition systems are fitted, and are independent throughout. A Bosch high-tension magneto is employed, the spark plugs being placed at the sides of the cylinders and directly in the inlet valve ports, while a set of six non-vibrating coils synchronized by a master vibrator, and supplied with current from a storage battery, comprise the emergency system, for which the plugs are placed over the inlet valves. The cooling water is circulated by means of a centrifugal pump driven by an independent shaft. The cylinders are of the T-head type with oppositely disposed valves actuated by direct thrust from independent camshafts, the valve tappets being provided with fibre blocks, making the motor silent running.

The Steering Pillar is a steel rod of liberal diameter. At its lower end it has a multiple thread of extreme accuracy turned on it. A heavy drop forged steel block nut is threaded

to correspond. Formed integrally with this nut are the arms of a trunnion, engaging hardened die blocks adapted to slide in the jaws of a forked lever. The nut is thus held from turning, and the revolution of the steering pillar causes it to move up or down. This motion is multiplied and transmitted to the steering wheels through a series of levers. Spring cushioned joints are employed to absorb vibration, and a ball thrust bearing under the steering pillar permits accurate adjustment for wear. This bearing is rigidly held by a special locking device. The steering knuckles and spindles are one piece drop forgings of nickel steel.

Final drive is by propeller shaft, a large universal being provided at the forward end, and a universal slip joint at the after end of the shaft.

The torsion rod is a triangle of seamless steel tubing, having its apex carried in a spring-cushioned, hinged joint, riveted to the after transverse member which supports the gear-set. At its base, the triangle is pivoted on a substantial bolt passing through the bevel gear housing.

The axle shafts are of heat-treated chrome nickel steel, and are directly attached to the wheels. The inboard bearing of the axle is of the Hess-Bright annular ball type, while the outer one is a Timken roller-bearing, which possesses superior ability to withstand combined radial and thrust loads. This quality has

been responsible for the adoption of the Timken bearings for the front wheels altogether. In the differential, and bevel gear drive, Hess-Bright bearings are fitted.

THE BRAKE. Whether it be more important for a motor car to run or to stop is something governed entirely by circumstances. Weight and speed have now reached a point where too much attention cannot be devoted to stopping ability. Good practice sanctions getting under way smoothly. But the necessity for stopping is governed by a time factor over which the driver frequently has no control.

With each increase in size and weight, there should be a corresponding enlargement of the braking surface, and strengthening of the brake rigging, far in excess of normal requirements. The adoption of the three-quarter elliptic type of spring at the rear in connection with the drop frame, permits of a most effective arrangement of the drop-forged steel brake hanger. It affords the maximum leverage without any increased effort at the pedal or side lever.

On the Pierce-Arrow cars, both the running, or pedal brake, and the emergency brake are located in special drums on the driving wheels, thus relieving the transmission of all braking stresses. The emergency brake is operated by the side lever, and causes the lined shoes to contract on the external faces of the drums. The pedal brake, acting through a heavy cam, ex-

pands a similar set of shoes against the inner faces of the drums. This brake is interconnected with the clutch, disengaging the latter automatically before the brakes can act. In order that the motor may be employed as a brake, the emergency brake and clutch are not interconnected. The braking effort at the rear wheels is equalized by transverse compensators.

Power Driven Air Pump. The modern type of Pierce-Arrow cars are now equipped with a power driven air-pump for inflating tires, and other purposes. This pump is located on the left-hand side of the motor forward, and is bolted directly to the side member of the frame in a vertical position. It carries on its shaft a large bronze gear, designed to mesh with a small steel pinion splined on the water pump shaft. To determine the positions of meshing and disengagement, a spring and ball device is employed. The small pinion is slid into engagement with the pump gear when the motor is stopped, and the latter is then run at from 400 to 500 revolutions per minute, at which speed the pump will inflate the largest tires employed to a pressure of 90 pounds to the square inch in a few minutes. The pump is placed beneath the hood and is entirely out of the way when not in use, though so arranged as to be very accessible when wanted.

Picric Acid. Gasoline will absorb or take up about 5 per cent of its weight of picric acid. The addition of a small quantity of kerosene

will enable the gasoline to absorb about 10 per cent of picric acid.

Picric acid is only dangerous when fused, or when in a highly compressed state.

An increase in motor efficiency of about 20 per cent is claimed for the picric-gasoline mixture.

About three-tenths of a pound of picric acid is required for each gallon of gasoline. The mixture should be allowed to stand for two days, agitating occasionally during this time, then strain through two or three thicknesses of very fine muslin before using.

It must be remembered that picric acid is an etching ingredient, which is another way for saying that it will destroy the cylinder walls.

The explosive force of picric acid is very much overrated. If thrown upon a red hot plate of iron, it simply burns with a smoky flame, and striking a small quantity of it upon an iron anvil will not explode it.

Pipe Nipples. Nipples are always ordered by the nominal diameter of the pipe, and the overall length of the nipple. Table 15 gives the standard lengths of nipples of varying diameters, also the number of threads per inch and the outside diameter of the pipe.

Pistons. The piston used in a gasoline motor cylinder is of the single-acting or trunk type. It is made of an iron casting which is a good working fit in the cylinder. Around the upper end of the piston three or four grooves are cut,

and in these grooves the piston-rings fit. The rings are made of cast iron, and the bore of the ring being eccentric to its outer diameter, there is a certain amount of spring in them, and so pressure is caused against the cylinder wall, preventing any of the expanding gases passing the piston.

The lubrication of the piston-rings is very important, for on that depends the proper working of the piston in the cylinder. In single cylinder motors, the piston-rings require frequent attention, and kerosene should be injected into the spark plug opening at frequent intervals. Occasionally the cylinder should be taken off, and the rings cleaned with a brush and kerosene. In multi-cylinder motors, this constant attention is not required, for in addition to the splash system of lubrication, usually, there are pipes leading to the cylinders,

TABLE 15.

LENGTH OF STANDARD PIPE NIPPLES.

Nominal Diameter.	Outside Diameter of Pipe.	Threads per Inch.	Over-all Length of Nipples.					
			Close.	Short.	Long.			
1/8	.40	28	3/4	1 1/2	2	2 1/2	3	3 1/2
1/4	.54	18	7/8	1 1/2	2	2 1/2	3	3 1/2
3/8	.68	18	1	1 1/2	2	2 1/2	3	3 1/2
1/2	.84	14	1 1/8	1 1/2	2	2 1/2	3	3 1/2
3/4	1.05	14	1 3/8	2	2 1/2	3	3 1/2	4
1	1.32	11	1 1/2	2	2 1/2	3	3 1/2	4
1 1/4	1.66	11	1 5/8	2 1/2	3	3 1/2	4	4 1/2
1 1/2	1.90	11	1 3/4	2 1/2	3	3 1/2	4	4 1/2
2	2.38	11	2	2 1/2	3	3 1/2	4	4 1/2

through which oil is fed and so keeps them well lubricated. The speed of the motor being so much less, there is no danger of the oil being used up rapidly.

Piston Displacement. The piston displacement of a motor is the volume swept out by the piston, and is equal to the area of the cylinder multiplied by the stroke of the piston. The expression, cylinder volume, is sometimes confounded wtih the term piston displacement. This is erroneous, as the cylinder volume is equal to the piston displacement, plus the combustion space in the cylinder head.

Pistons, Length of. For vertical cylinder motors the length of the piston should not on any account be less than its diameter, while a length equal to one and one-quarter or even one and one-third diameters is better. For motors with horizontal cylinders the length of the piston, in any case, should not be less than one and one-third diameters, and if possible one and one-half diameters or over.

Piston Position. There is nothing more confusing to many motorists—not only to the beginner, but to many who are proficient in the general care and operation of their motor cars—than the relative various positions, in a four-cycle engine, of the four pistons on any of their four cycles of compression, work, explosion, and exhaust, this being the order of the cycles.

In the following illustrations the pistons are shown as they are usually placed in relation to

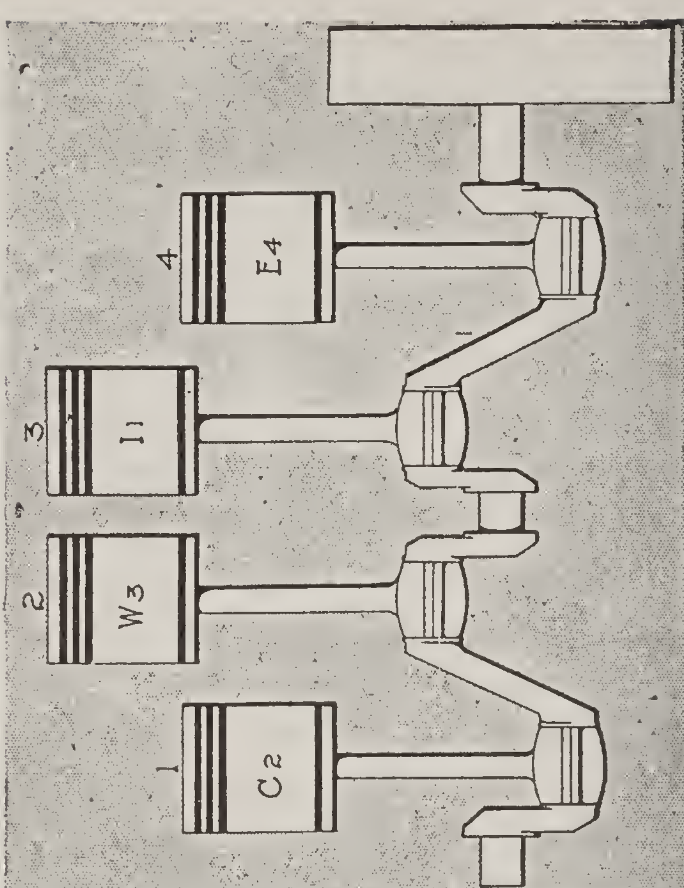


Fig. 256

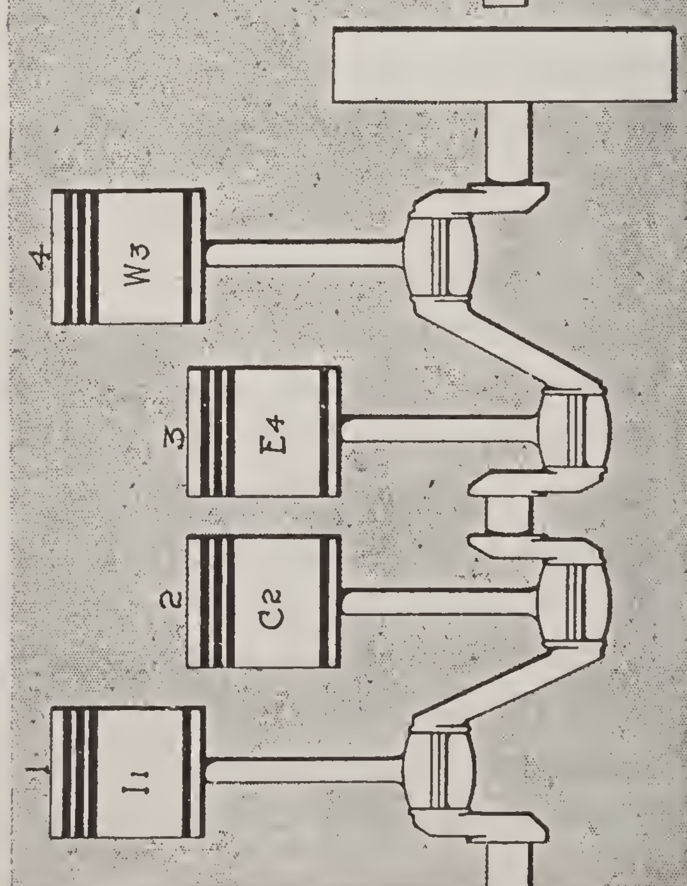


Fig. 255

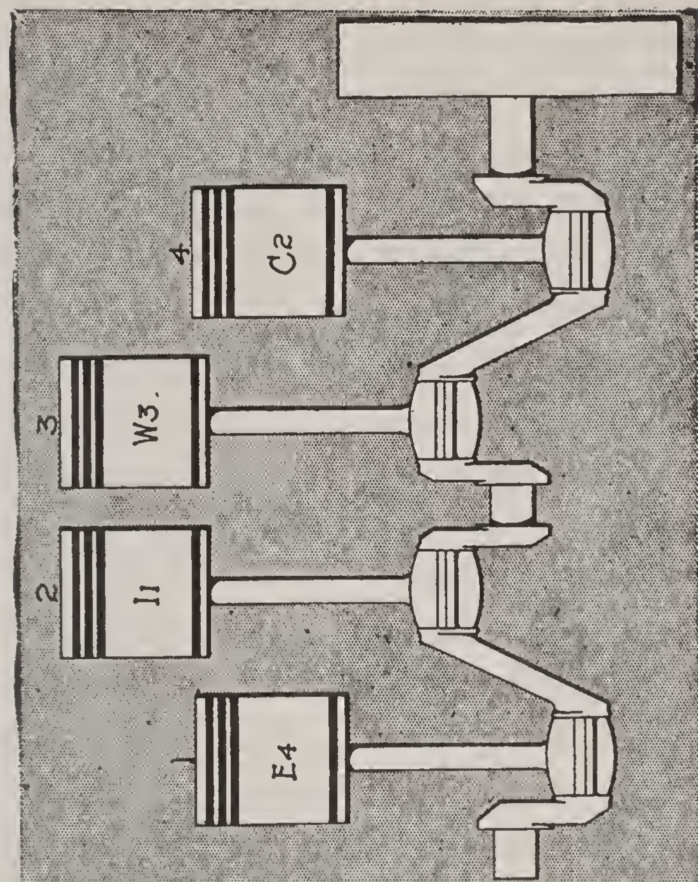


Fig. 258

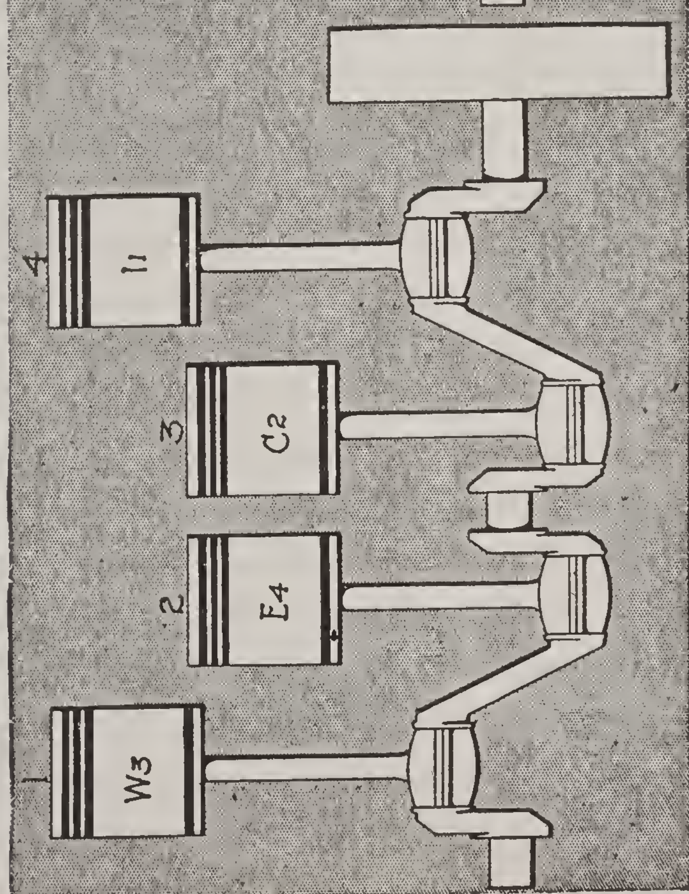


Fig. 257

one another. That is, pistons 1 and 4 are at the top of their strokes when pistons 2 and 3 are at the bottom, and, obviously, vice versa. The figures over the pistons in each diagram represent their order of number, counting from either end of the engine.

In Fig. 255, cylinder I is ready to descend on its intake stroke—having finished its exhaust stroke—and cylinder 4 is ready to descend on its working stroke—having finished its compression stroke. Cylinders 2 and 3 are ready to move on their up strokes, No. 2 on its compression, having finished its intake, and No. 3 on its exhaust, having finished its working stroke. The results are that the pistons are brought into the positions shown in Fig. 256. This means that cylinder No. 1, having completed its intake downward stroke, is ready for its compression up stroke; No. 2 has moved up on compression and is ready to go down on work; No. 3 has finished exhausting and is ready for intake and No. 4 has finished the work stroke and is ready to move up on exhaust. Piston No. 2, having completed its work stroke, the pistons are brought back to the positions shown in Fig. 255, but with an altered condition of the cycle represented by each, as shown in Fig. 257. The pistons are now ready to move to the positions shown in diagram 2, with an altered cycle condition. Cylinder No. 1 moves down on work; No. 2 up on exhaust;

No. 3 up on compression and No. 4 down on intake, see Fig. 258.

When the cycle of each has been completed, from the above starting points of No. 1, exhaust; No. 2, intake; No. 3, work, and No. 4, compression, the pistons are then back not only in the position of Fig. 255, but with the same condition of cycles.

This explanation has been in the order of the cylinder numbers, but the effect of each cycle of each cylinder will be easier traced if it be remembered that the order in which the cylinders work is: Cylinder 1, then cylinder 3, then cylinder 4, and then cylinder 2, and then repeat indefinitely. From this and the above illustrations it will be easily understood that as piston No. 1 goes down on its work stroke, No. 3 comes up on compression stroke, and is then ready for the work, which is a down stroke bringing No. 4 up on compression. No. 4 then goes down on work and brings No. 2 up on compression, then it goes down on work and brings No. 1 up on compression for the repeating of cycles. This shows that each synchronized pair, 1-4 and 2-3, always have one cycle between them as they move together, either up or down.

Piston-Rings. To ensure proper compression, it is absolutely essential that the piston-rings should be kept lubricated; consequently when the motor has been idle for some time, the compression at the start is often poor. Any failure in the lubrication while running will, of

course, have the same effect, such, for example, as in the case of overheating, or when the supply is intermittent. Sometimes the piston-rings get stuck in their grooves with burnt oil, through overheating, and the compression escapes past them. Thorough cleaning with kerosene, and fresh lubricating-oil will settle the matter. In motors where the rings are not pinned in position, the slots may work round so as to coincide. In this case they will have to be moved around. Sometimes burnt oil may, apparently, have the opposite effect on piston-rings, for by causing the piston to grip in the cylinder, it will produce considerable resistance, and the operator might erroneously think in consequence that his compression is good. In every case, after a long run, a little kerosene should be injected into the cylinders to clean the rings.

PISTON-RINGS—METHOD OF TURNING. A pattern should be made from which to cast a blank cylinder or sleeve with two projecting slotted lugs on one end to bolt same to face plate of lathe. This blank should first be turned off outside to the required diameter, making it, of course, sufficiently larger to allow for the cut in the rings, after cutting from the blank. The blank should then be set over eccentric sufficiently to allow the thick side of the rings to be twice the thickness of the thin side after turning. The inside of the blank can then be bored out, and the rings cut off to the exact thick-

ness required with a good sharp cutting off tool. A mandrel or arbor shoud be made with two cast iron washers or collars to fit on it, one fastened to the mandrel and the other loose, with lock nut on mandrel with which to tighten up the loose collar. After the rings have been sawed open and a piece cut out the required length, they can be placed in a collar or ring about 1-32 to 3-64 of an inch larger than the cylinder bore, and slipped on to the mandrel one at a time of course, with the loose collar and nut off the same. The loose collar and nut can then be put on the mandrel, the ring clamped tightly between the two collars, the mandrel put in the lathe and the ring turned off, without leaving any fins or having to cut the ring off afterward as is done in many cases. This is the only way in which a perfectly true ring can be made.

Piston Velocity, Limitation of. The speed of rotation of an explosive motor is limited by the fact that the velocity of the piston must be considerably less than the rate of combustion of the explosive mixture, in order that the motor may develop energy or do work. The practical limit of piston velocity is said to be between 14 and 16 feet per second.

Piston Head Scraper. In most engines the piston heads can be scraped clean of carbon without removing the pistons from the cylinders, by means of specially formed scrapers introduced through the opening over the valves, or

through the spark plug holes when the latter are horizontal. The form and size of scraper will depend on the particular engine, but almost any suitable form may be made from 5-16-inch steel tubing about 12 inches long having the ends hammered flat, and turned over at right angles in a vise. The ends are then filed straight, and sharp, and the shank of the scraper may be bent to right or left, if necessary, or left straight. Frequently two scrapers will be needed in order to use both right and left hand bends. The advantage of tubing for this purpose is that no blacksmith work is necessary.

Platinum. The contact points of the vibrator of an induction coil should always be of platinum. German silver or any other metal spoils the quickness of the break on account of the greater tendency of the contact-points to carbonize, when of any other metal than platinum. Spark plug points should also be of platinum or iridio-platinum, which is better yet, as it is more capable of withstanding the intense heat in the combustion chamber than the platinum itself. Any other metal than platinum (except gold) will turn green or black if tested with nitric acid.

Polarity. To ascertain the polarity of the terminals of a storage battery or light circuit, place the ends of the wires on the opposite ends of a small piece of moistened litmus paper. The

wire on the side of the paper which has turned red is the negative pole of the battery.

Porcelain. Porcelain tubes used for the insulation of the center rod of a spark plug have higher insulative properties than lava or mica, but on account of the liability of the porcelain to break from too sudden change of temperature, it is not as reliable as other forms of insulating material.

Pounding—Causes of. The most obvious cause of pounding is that of a spark advanced too far. This, however, nearly always occurs upon hills, in deep sand or mud, or elsewhere, whenever the engine is laboring very hard. In the case of too far advanced spark, manipulation of the spark would only make the pound worse than ever. So, too, if the spark was normally set too far advanced, it would pound more at high speeds than at slow, just the reverse of the actual case.

Preignition causes pounding, and is itself caused by overheated piston or cylinder walls. Glowing points or deposits of carbon within the cylinder, as well as faulty or uncertain ignition also cause it. Leaks in the chamber are sometimes the cause of pounding, so too, are looseness of parts. Among the latter may be cited: connecting rod bearings, main bearings, loose flywheel, cracked flywheel; other lost motion. Beyond these things, the only other cause of pounding is that of some moving part which strikes as it rotates.

Preignition—Causes of. If the inside surfaces of the combustion chamber are free from sharp corners or projections formed in casting, preignition is probably due to the combined influences of high compression, and carbon or dirt on the piston head. Next to the exhaust valve itself the piston head is the hottest part of the engine, since it cannot be water cooled. For this reason it is much more important to keep the piston head clean than the other surfaces exposed to flame, and this is best accomplished, first, by the use of a good non-carbonizing oil, and, second, by thoroughly screening the air intake. If preignition is troublesome it will pay to fit a dust screen underneath the engine in case none is already provided, since whatever dust touches the piston head will be held there by the oil, and will be fully as effective in causing preignition as the same amount of carbon. The intake itself should draw air through at least one, and preferably two or more fine wire gauze screens of sufficiently large area to permit the air to pass through them slowly. These screens should be removable, and should be inspected, and cleaned with gasoline and a toothbrush as often as may be necessary. It will be found that the fitting of a suitable dust screen beneath will make an immense difference in the amount of cleaning, which the gauze screens require. In the manufacture of high classed motor cars the greatest care is taken in scraping the walls and dome of the cyl-

inder castings forming the combustion space, the aim being to remove every projection that might cause a pre-ignition point as also to remove every burr, or rough spot to which foreign matter would adhere. The lubrication system of a car is a most important factor in the elimination of preignition due to the proper amount of oil being fed to the cylinders at all times.

Pump Lubrication. Grease is the proper lubrication for a pump, and it should be stiff enough so that the water will not wash it away. Be careful not to use too much, as highly heated water tends to carry it into the radiator and deposit it there, where it is liable to clog the circulation, or at least reduce the efficiency of the radiator.

Pumps—Centrifugal. In this type of pump the height of lift is governed by the tangential force. Owing to this fact centrifugal pumps for use on automobiles may be made of aluminum for the housing, as it is both light and strong, fully able to withstand the pressure, there being no rubbing surfaces. The wheel, however, should be made of phosphor bronze of a good grade. In these pumps the suction inlet is usually at one side surrounding the axis, see Fig. 259. The pump should be geared to a speed as high if not higher than the crankshaft speed. The minimum peripheral velocity of the pump wheel should be 500 feet per minute. For automobile service the general rule is to have a

three vane wheel, and the curving is away from the direction of rotation.

Pumps, Water Circulating. If steam is seen coming from the relief, or outlet of the water

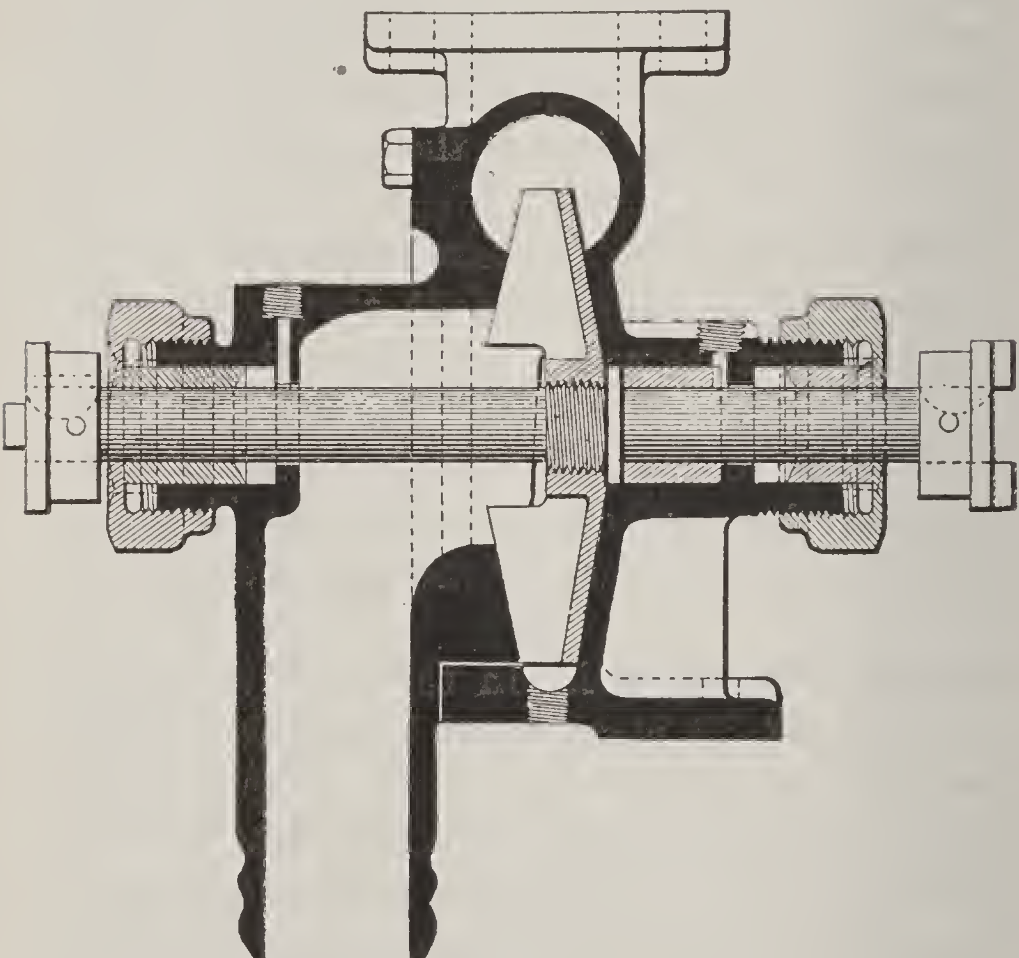


Fig. 259
Section of a Centrifugal Water Pump, Showing Entrance of Water at the Side, Around the Shaft

circulating system, look for a blockage of the circulation, or failure of the pump.

If some of the radiator tubes are cool and others are hot, look to the pump.

To test the pump before starting, run the motor for a few minutes. Then ascertain how

long it takes before the top radiator tubes are thoroughly hot. If the heat of the pipes is uniform the circulation is all right.

Radiator—Water-Cooling. The design of a radiator should be such that the maximum of surface is exposed to the air and the greatest freedom afforded for the circulation of the water. As a circle presents the minimum surface, it would appear that a circular pipe is not the best shape for a radiator tube. There are, however, many reasons in favor of the circular section, one of which is the small resistance offered to the flow of the water. With a circular shape the minimum weight of tube is obtained for a given cubic content of liquid, and the greatest strength also for a given weight. A flattened tube section is often used, and is made up to represent in appearance the cellular radiators which have recently come into use. If the cellular radiators are well made, they have the advantage of being more easily cleaned of mud than any other design. The number of joints forming a honey-comb radiator are likely to be a cause of leakage, and such a radiator is far more difficult to repair on the road than the tubular type with radiating fins or discs.

Radiator, Cooling Surface Per Horsepower. Motors using the thermo-siphon or natural water circulation require about 5 square feet of radiating or cooling surface per horsepower.

Radiator—Combination Water Tank. Four

styles of combination water tank and radiator are shown in Figure 260, having vertical cooling tubes with radiating discs, honey-comb or cellular form of radiation and horizontal tubes, respectively.

Radiator Cap Stuck. The commonest cause

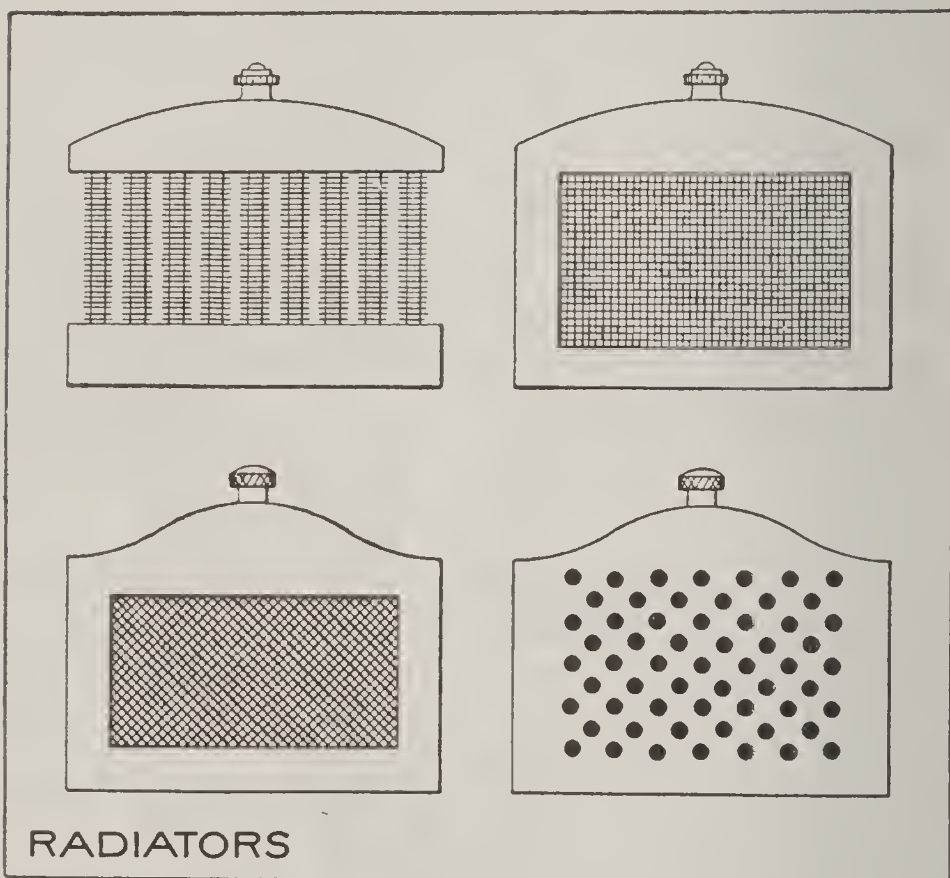


Fig. 260

of a radiator cap sticking is simply expansion of the threaded ring on which it screws. In other words, it sticks only when hot, and is unscrewed easily when cold. The time to refill the radiator therefore is before rather than at the end of a run. If, however, refilling is necessary when hot, for instance, after a stiff hill-climb,

the simplest plan is to cool the top of the radiator and the base of the ring under the cap by pouring water thereon, being careful not to get the water on the cap itself.

Repairs—Tools for. In Fig. 261, three types of valve lifters are shown. B and C are of the same principle, and quite efficient in almost any case; but A, when properly operated, and on its respective motor, is more quickly applied,

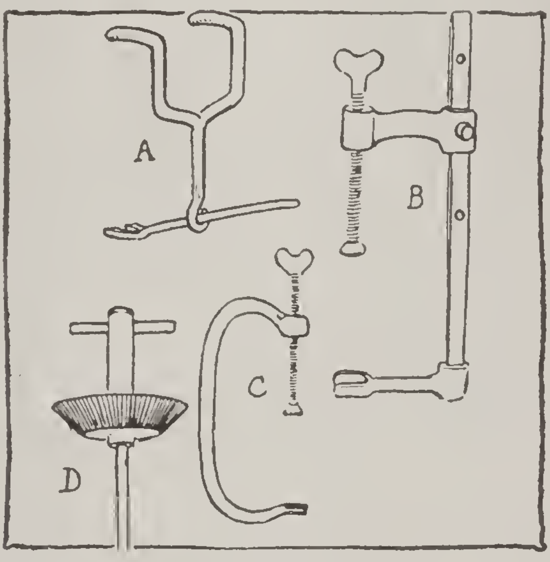


Fig. 261

and consequently a time saver. D is a valve-seating tool, supplied as special equipment by one of the large motor car manufacturers.

In Fig. 262 are shown a couple of spanner wrenches and one or two other tools that are quite uncommon but quite necessary in the work to which they are adapted. A is made from a piece of steel tubing and used on packing glands—the tube to slip over the shaft—and the small lugs at the end engage corresponding

recesses in a packing nut. B is representative of a valve-grinder, designed especially for the valves in certain motors. The spanner C is required to conveniently remove certain types of cylinder plugs; while D, which approaches the conventional, is used in adjusting bearings of a particular type.

There is probably a greater variety of wheel and gear pullers now in service than of any

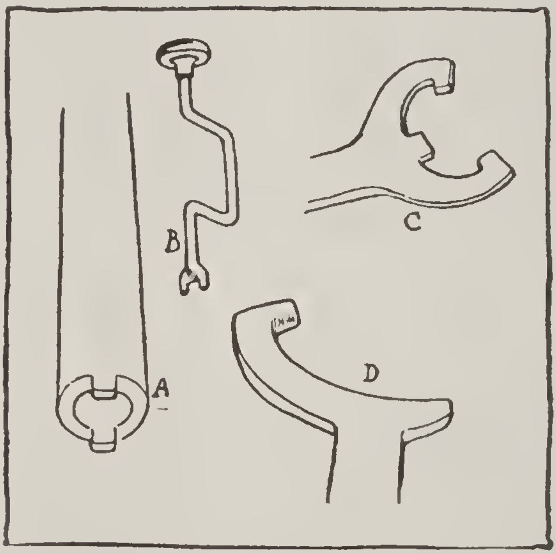


Fig. 262

other special tool. In Fig. 263, A looks very much like the standard adjustable wheel and gear puller for sale in all supply houses; and it practically is the same except that the hooks are larger and twisted in opposite directions and at right angles to the beam. It is found useful in removing road and flywheels and the like. B is a non-adjustable tool made especially for removing flywheels. C and P are road wheel pullers, and are included in the regular equip-

ment of tools supplied with the cars of two prominent manufacturers. C is part of the Rambler tool equipment and is used in connection with their spare wheel; and P represents the type of wheel puller supplied by the Pierce-Arrow. E is a gear-puller designed to remove the half-time-gears of an Oldsmobile, the two

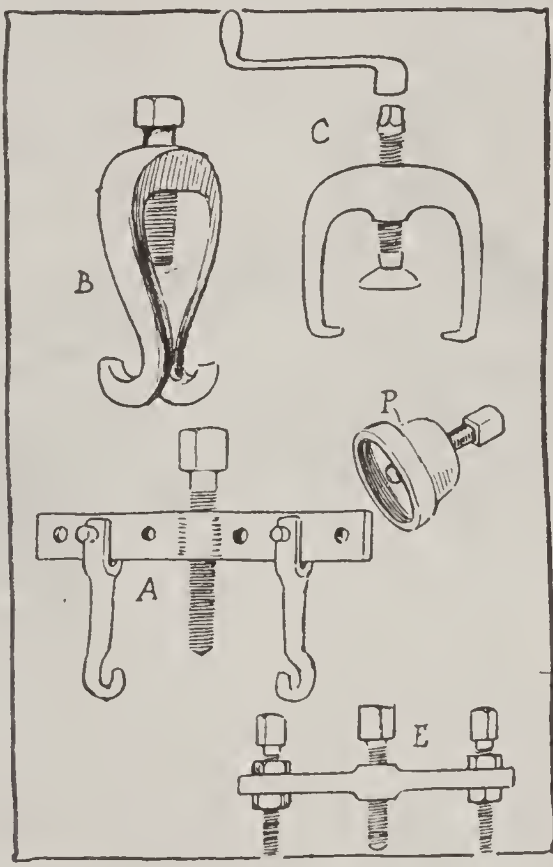


Fig. 263

side-screws being intended to fit into threaded holes in the web of the gears.

When the Jack is Missing. Should the jack be missing or broken, an efficient substitute can be rigged from a large stone or a number of bricks piled one on another until the height is sufficient to lift the wheel from the ground.

Having gotten the stone or piled the bricks one of the floor-boards can be utilized as an inclined plane and the car backed up until the axle rests on the top of the pile. When the work has been performed, the axle will have to be pushed off the pile, but as the drop is inconsiderable no harm can come to the tire. Where stake-and-

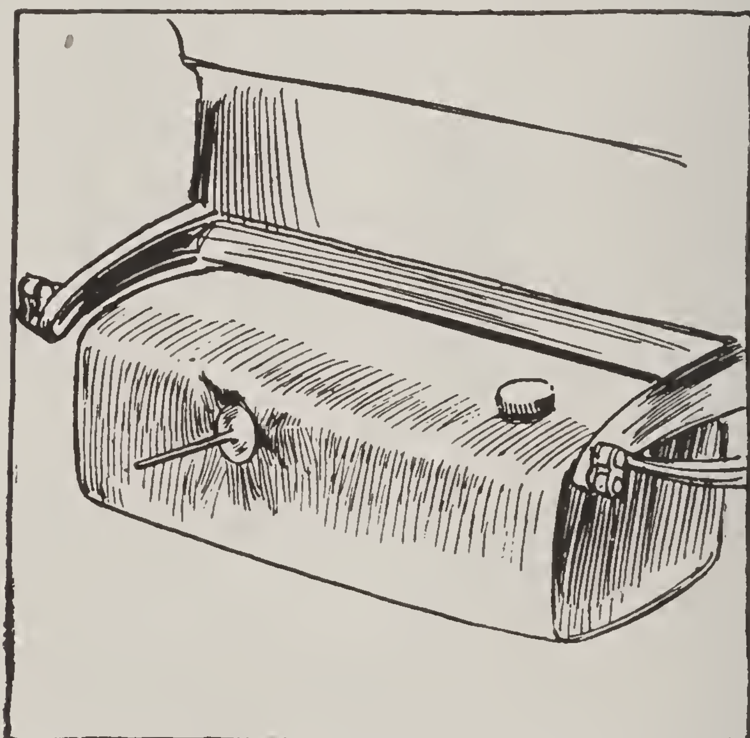


Fig. 264
Removing Dent in Gasoline Tank

rider fences abound, one of the rider timbers can be utilized as a lever, with a stone as a fulcrum to raise the axle, supporting the latter with another stone during the repair, and gently easing down the axle when ready to proceed.

Removing Dents. An easy method of removing dents consists of soldering a piece of wire to the bottom of the dent, then pulling the de-

pressed portion out to its proper position. When the dent happens to be in an oil, or gasoline tank, or a radiator, an old valve can be most effectively used in place of the wire, as shown in Fig. 264. The top surface of the valve is filed smooth and bright, then cleaned with soldering acid and tinned with solder. A flat surface of the same area, and as near the bottom of the dent as possible, is treated in the same manner, and the valve sweated on. This sweating on is done by placing the prepared portion of the valve against the tinned surface of the dent, and then applying heat with a torch till a fusion of the solder takes place. The heat should then be removed and the solder allowed to set. When cool, it will be found that with the valve stem as a handle and lever, and probably a few light taps with a hammer around the edge of the dent, the deformed part can be most easily straightened out.

Reversing—Backing Up. Among other things connected with driving which is apt to be neglected, is reversing, or driving a car backward. Usually a car is never reversed for more than a few yards at a time and the maneuvering involved requires no great skill. Steering a car when running backwards is diametrically opposite to that when running forward. A turn of the wheel to the left steers the car in the opposite direction to the right, and vice versa. The usual mistake made in reversing is in turning the steering wheel too far, and describing

zigzags in the road as a result. The autoist should remember that the reverse gear of a sliding change gear should never be engaged until the car has been brought to a full stop.

Rheostat. A rheostat is a device for regulating the flow of current in a closed electrical circuit, by introducing a series of graduated resistances into the circuit.

Rubber, India. All articles made of commercial rubber should be kept from contact with oil, kerosene, gasoline or grease if they are to be kept in good condition. Vulcanized rubber should not be exposed to a temperature of more than 130 degrees, Fahrenheit. Commercial or vulcanized rubber contains not to exceed 30 to 35 per cent of pure India rubber, as its stretching quality, stickiness and rapid deterioration under the action of light and air make its sole use undesirable.

Rubber Cement, How to Make. Marine glue, so-called, is an excellent cement. This consists of one pound of caoutchouc to one gallon of coal tar naphtha, and twenty pounds of shellac. Heat gently and pour on metal plates to solidify. When needed, melt. By using more naphtha, this is made thinner so as to stay liquid. The sulphur in this is in the caoutchouc, but if found insufficient in any one case, more sulphur may be added to the cement in the powdered form, when making it up, or if necessary, when remelting.

Another excellent cement is gutta-percha

cement. The composition of this is two parts of gutta-percha to one part of common pitch. It is melted together, and well-stirred in the melting, the stirring being fully as important as the materials. When thoroughly melted and stirred, it is poured into cold water. This makes it into a hard brittle substance, which softens at a low temperature, and at 100 degrees is a thin fluid. Like the former recipe, this carries its own sulphur in the gutta-percha, but if more is necessary, it can be added as a powder. In this case, it is not advisable to add the sulphur during the remelting process, but it should be put in while making up a batch of the cement.

As a rule, as little cement should be used as is possible to make a good job. Moreover, all cement should be given plenty of time to dry. Rubber surfaces to be united should be thoroughly cleaned, either with naphtha or with a thin cement. When the latter is used, it is brushed over the surface very lightly, using a fine brush, and then the surfaces are heated gently. This helps the whole operation, because it both softens the rubber, and evaporates the solvent, which is then unnecessary to complete the operation, having served its usefulness.

In addition to the various substances mentioned before for cements, it is very often necessary to have the cement dry very rapidly. In these cases, specific driers are added, and may usually be added to any cement at will, the quantity added being measured only by the re-

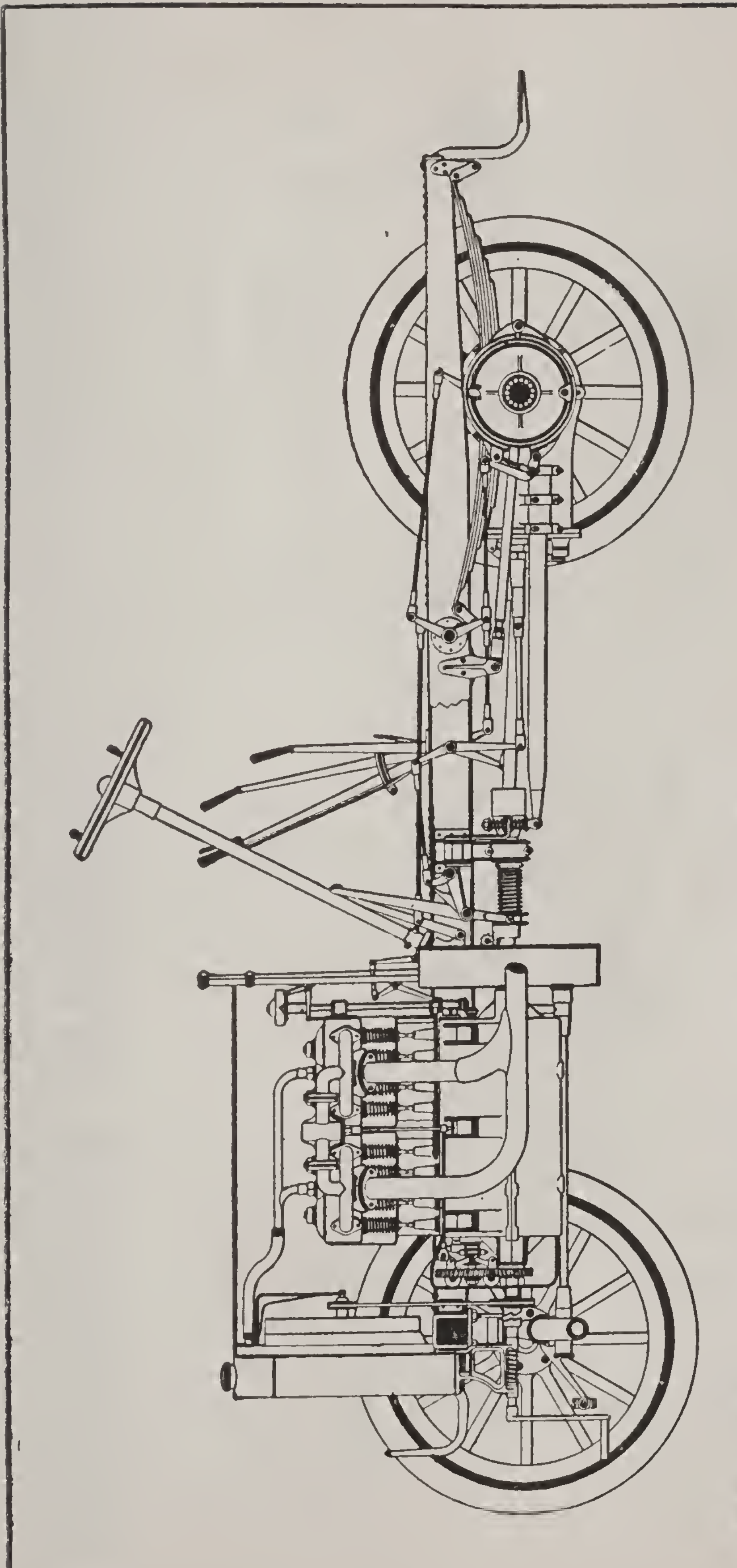
quired speed in drying. Then there are cases where certain degrees of tenacity are required. For these, other gums are added, as rosin, mastic, gumlac, etc. These, however, should be used only when needed, and much discretion should be used in adding them to an already very satisfactory cement.

Running Gear. A complete running gear includes the frame, springs, wheels, motor, speed-change-gear, axles and the machinery of the car except the body. The French word, chassis, is sometimes used to designate a running gear, but its use is not correct, as strictly speaking the term, chassis, applies to the frame only, or at the most to the frame and springs.

Figure 265 illustrates a vertical section of a running gear equipped with a vertical four-cylinder motor, and longitudinal propeller-shaft drive, by bevel gearing to the live rear axle.

A plan view of a running gear with double side-chain drive and rigid rear axle is shown in Figure 266. The motor is also of the vertical four-cylinder form. The water cooling system in both cases is by rotary pump, combination tank and radiator, and fan, as shown.

Scratched Cylinder. The cylinder may be temporarily fixed by taking it to a first-class tinsmith and having the scratches filled with silver solder. The soldered places must be then carefully scraped flush with the bore of the cylinder. The best way is to have the cylinder rebored and the piston-rings re-turned.



RUNNING GEAR

Fig. 265

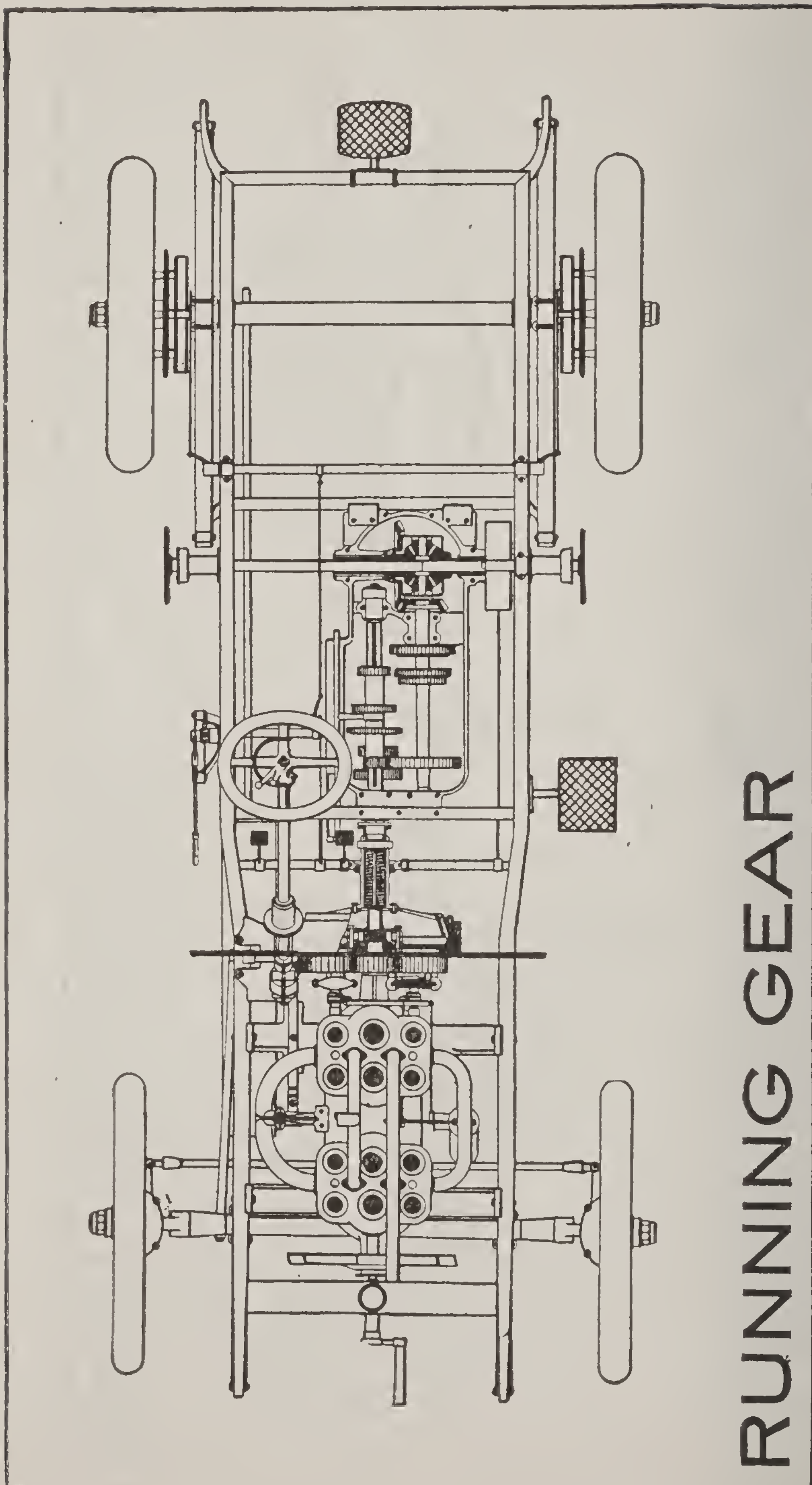


Fig. 266

If the scratches are not too deep the cylinder can be rebored,, and a new set of piston-rings made to fit the new bore. The limit to such an increase in bore is about one-sixteenth of an inch.

Screw-Driver, Uses of. A screw-driver is one of the handiest and most useful tools on a car. It can be used to grind in a valve, to press a valve spring out the way, or to hold a valve spring up while the spring cap is being put on. It may also be used as a chisel to tighten a loose nut, which otherwise cannot be gotten at.

Secondary Current. The current which takes its rise in the fine wire of the induction coil, and which flows through the wire to the spark plug, is induced in the fine wire by the sudden reversal of the magnetism of the iron core.

This change of magnetism is caused by the sudden interruption of the primary current.

Self-firing, Causes of. If the motor should continue to run after the switch has been opened, it is due to an insufficient supply of lubricating oil, causing the motor to overheat, or to the presence of soot or some projection in the combustion chamber becoming incandescent. It may also be due to lack of water or to the water circulation working poorly, causing the motor to overheat.

Shaft Drive. The principal advantages which may be advanced for the shaft drive are, absence of noise, convenience with which all the parts may be housed in oil and protection from

dust. It is especially adapted for use upon cars carrying their engines in front, with the crankshafts parallel with the length of the car, as the direction of the power shaft does not have to be changed until the rear axle is reached, and as the power must also pass through one set of bevel gears, it is more efficient.

The principal disadvantages of the shaft drive are that it is difficult to repair; it is some-

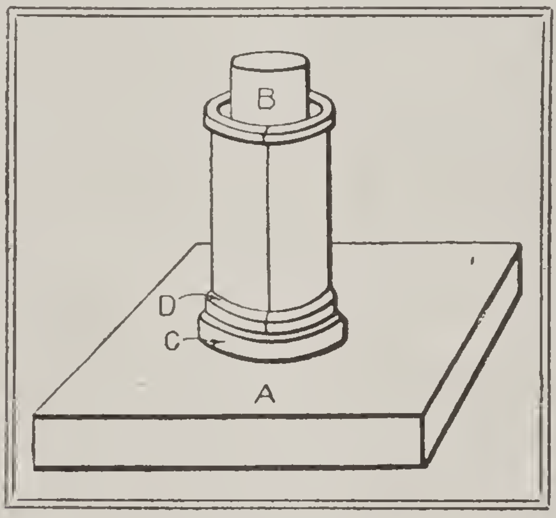


Fig. 267
Pouring Parson's Metal

what more complicated; it has considerable end-thrust and it is claimed that it is harder on the tires.

Shop Kinks. To reline a journal box with Parson's white brass, proceed as follows: Prepare a reasonably smooth cast iron plate A, Fig. 267, which is bored to receive a vertical mandrel B about 3/16 inch smaller in diameter than the finishing bore of the box. An annular brass ring C, about ½ inch wide, and whose in-

side diameter is about ⅛ inch smaller than the outside diameter of the end flange D of the box to be lined, is then located on the iron plate concentrically with the mandrel, and secured by means of pins or otherwise. This ring serves as a support for the box itself, and in the process of pouring, the space between the ring and mandrel is filled with white brass which is afterward turned off. Any imperfect metal which may be poured will

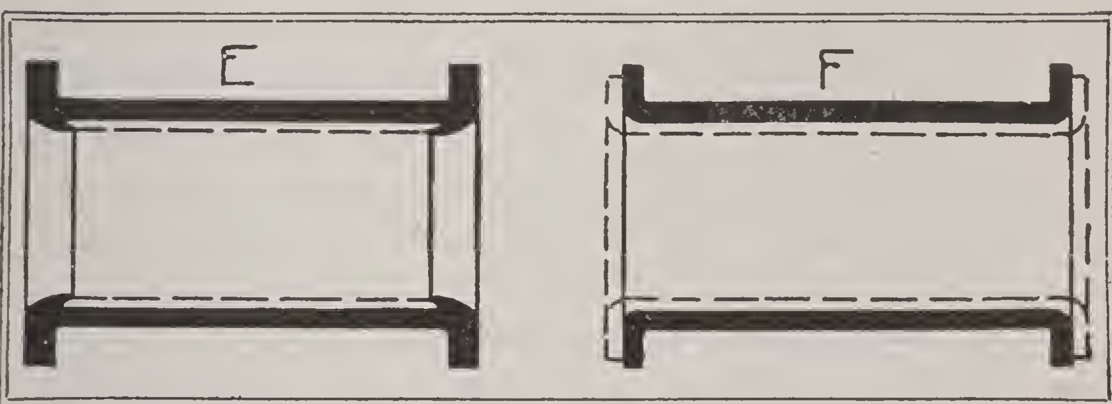


Fig. 268

find its way either into this space or into the space above the box, leaving the lining of the box itself perfectly sound. The box itself is assumed to have been suitably counterbored and recessed to hold the lining as shown in the sketches E and F, Fig. 268. It is preferable to use the arrangement shown at F and allow the lining to extend beyond the ends of the box, and form the outer surface of the flanges. In this case the diameter of the flange formed by the lining will be the inside diameter of the sup-

porting ring, which will be slightly smaller than the diameter of the flange of the box itself.

The halves of the box—if it is split—are wired together and the box and the mandrel are heated by torches and assembled as shown in the sketch. A second ring—not shown—similar to the supporting ring is placed on the top of the box, and all the cracks are luted with moist fire clay. Meanwhile, the white brass has been melted in a kettle to a fairly high heat somewhat higher than the pouring temperature. While it is being melted, it is kept covered by about 1 inch of powdered charcoal, which excludes the air. When the maximum temperature is reached, the charcoal is quickly skimmed off and a handful or two of powdered salammoniac is thrown on. The salammoniac is immediately volatilized and forms a heavy, though colorless gas which shuts off the air from the surface of the metal and causes it to stay bright. The pouring is then done with all possible haste, and on cooling the metal will be found perfectly homogeneous and solid. If the box is split the lining can be condensed by pening. If the box is solid, the lining is simply bored to the proper size.

To Restore a Sagged Frame. A frame which is sagged to the extent of permanent deformation can be restored so as to approximate its original shape, by heating it in a charcoal fire with an air blast. To do this properly, it will most likely be necessary to cut out the rivets,

so that the side members can be handled independently. A good plan of procedure is to inclose the bent portion of the frame in a section of stovepipe of sufficient size in which the charcoal fire is built. A length of 1-inch gas pipe, closed at one end, and having 5/16-inch holes, drilled at intervals of about 6 inches, is laid in the bottom of the pipe and furnishes the air supply from a bellows. When the charcoal fire is well kindled, the frame is introduced upside down, and is supported at the ends. The fire is then concentrated on the bent portion, and as the frame becomes hot it will straighten itself. It must be watched carefully and the air blast stopped as soon as the frame is seen to be straight. Most of the frames used in American cars are ordinary carbon steel, and require no special treatment. It will be well, however, on stopping the air blast to shift the stove pipe to a cooler portion of the frame, to permit the part which has been straightened to cool as quickly as exposure to the air will permit. A frame which has been sagged and straightened in this manner will require to be trussed to prevent recurrence of the trouble. As conditions vary so much the best rule to follow is to observe the truss arrangement on some similar car. The struts should be about 4 or 5 inches long, and should be located at the spots where the sagging has occurred. The truss rod itself should be about ½ inch in diameter, and drawn taut by a turnbuckle, which may be finally

tightened when the chassis has been assembled.

SPANISH WINDLASS. The old fashioned Spanish windlass, in Fig. 269, may be occasionally employed where no other hoist is available. It is extremely handy in setting, and lining up motors, transmissions and rear axles. It consists of a round bar or piece of pipe, a piece of rope, and a lever such as a small crowbar or

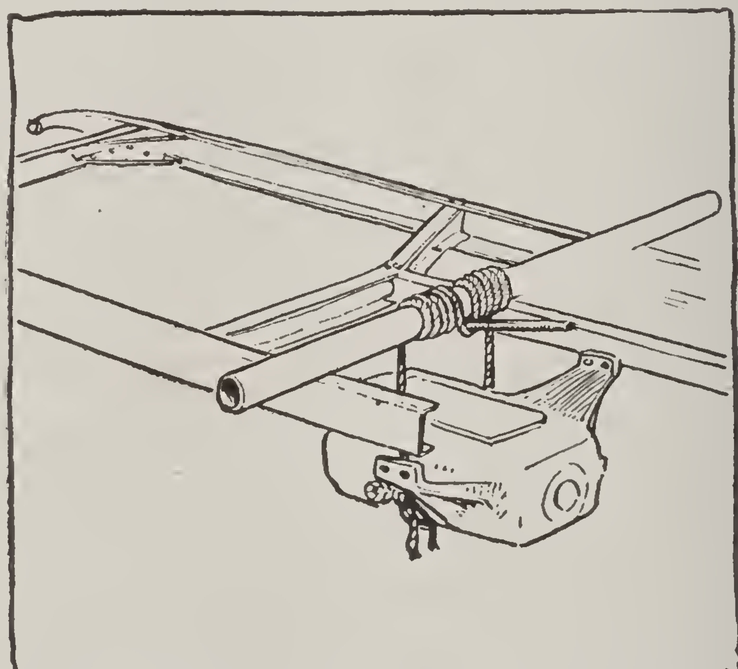


Fig. 269
Spanish Windlass

jack-handle; all of which are quite common to the ordinary repair shop. The round bar is laid across the side members of the frame, the rope is made fast to the object to be hoisted, a loop of it is wound around the bar as shown, and the lever inserted in the end of the loop. Although this is as old as the hills, it is not uncommon to see a man lying on his back, in a

most uncomfortable position, holding a heavy transmission case up into place while another is trying to locate the bolt holes, and adjust the liners; whereas, if this makeshift windlass were employed, one man could raise and set the gear-box with much less trouble.

STRAIGHTENING SPINDLES. In Fig. 270 a tool is shown which is used in a local repair shop, for straightening spindles. The tool, which is of heavy construction, is placed in a vise; the

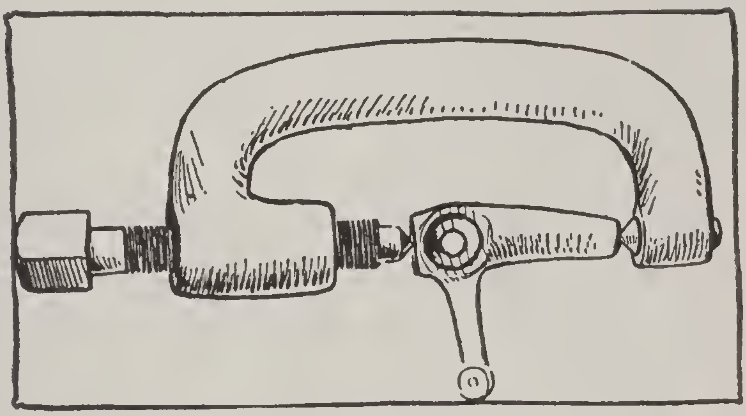


Fig. 270
Tool for Straightening Spindles

spindle is heated to a red heat, the ends cooled off with water, and placed between the centers, as illustrated. A lever is then placed between the bent portion of the spindle and the shank of the tool, so that when pressure is brought to bear on it, the spindle arm may be brought back into its normal position.

CLEANING ALUMINUM. Aluminum, such as used for foot-boards of cars, may be cleaned by using hyposulphate of soda, as this substance is a solvent of aluminum tarnish. The dirty sur-

face should be washed with a strong solution of the hyposulphate; then rinse the surface with water and dry.

Care of Tire Pump Leather. The proper lubricant for the cupped leather washer of the tire pump piston is vaseline. Oil is too thin and it tends to work into the rubber hose, and even into the tire itself if too much is used. Vaseline, on the other hand, clings to the leather and lasts a considerable time. If the leather becomes dry it does not hold air well, and pumping to high pressure becomes impossible, while the labor of pumping even to low pressure is greatly increased.

Replacing Broken Ball. When replacing a broken ball in a ball bearing it is better to renew the whole set, unless the new ball can be carefully gauged to be of the same size as the others. If this is not attended to, the new ball, having to bear more than its share of the weight, quickly succumbs. The greatest care should be taken, of course, to use grease free from grit, and to clean the balls and bearings before they are replaced.

Cleaning Tops. Tops may be cleaned by using gasoline, a little ivory soap and a brush. Sometimes, however, when cleaning with gasoline the water-proofing quality of the materials may be destroyed. This can be restored by an application of paraffine. Dissolve the paraffine with gasoline and apply with a clean brush, the gasoline will carry the paraffine into the fabric

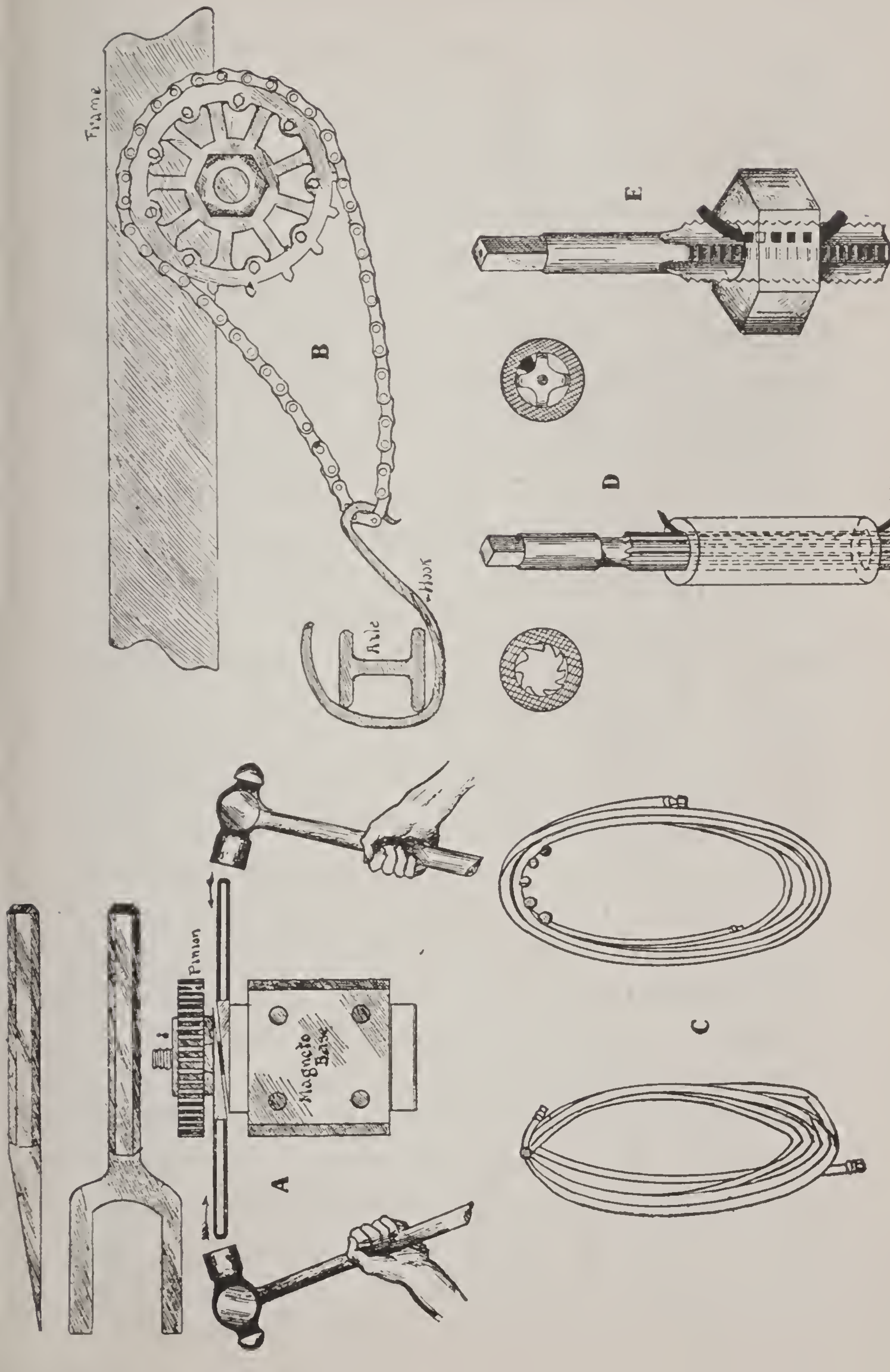


Fig. 270a

and will evaporate, leaving the paraffine in the fabric.

Useful Hints. At A, Fig. 270a, is shown a simple tool found to be universally useful for wedging off magneto driving pinions, and other small members fitted to coned shaft ends, with or without key retention. This can be easily made from a large file, or any piece of steel of sufficient dimensions, depending upon the work to which it would be applied. The opening in the fork need not be more than three-quarters inch for the average magneto, the tines about two inches long, and three-eighths inch wide and taper from nothing to about one-quarter inch at the thickest part. Two of these are needed and are placed back of the gear, the tapered portion of one piece resting on that of the other, as shown. To remove the gear the ends are driven in toward the centre at the same time. This exerts a lifting effort, due to the wedge action of the tools immediately back of the pinion. The advantage of this method is that the shaft on which the gear is mounted is not subjected to any side strains, such as would result if attempts were made to drive off the gear by holding an S wrench back of the gear and driving against it with a hammer. When removing worn sprockets from the counter shaft in order to replace them with new ones, trouble may be experienced in loosening the nut especially if the rear wheels have been removed. In such cases the chain may be utilized

to hold the sprocket in the manner shown at B, Fig. 270a, by anchoring it to the axle with an S hook made of three-eighths inch cold rolled steel rod The sprocket will be firmly held and the nut removed without difficulty.

Although some grades of rubber hose are better than others, unless properly cared for even the best will deteriorate rapidly. Among the factors which make for rapid wear are careless stowage and abuse. The hose is left on the wash stand, cars are run over it, and when it has served its purpose, it is thrown in a heap and oil and grease accumulations soon work havoc with the rubber walls. A good rule to follow is to have a place for everything and everything in its place. It is not unusual to see a coil of hose carefully hung upon a nail, as shown at C, each coil having a sharp "kink" in it, both top and bottom, as indicated. This sharp bend tends to break the fabric walls, and the hose soon leaks. The proper way of hanging a hose is to use five or six wooden pegs arranged around an arc of a circle, as shown. Under these conditions the coils take a gradual curve, and do not assume a sharp angle as when but a single point of support is utilized. If the hose is one of some length a reel should be used.

Often when fitting bushings and parts, and in general operations where reamers are used it is found that the tool will be just a trifle undersize, or that it is desirable to have the

reamed hole just a little oversize. In such cases a simple expedient, as shown at D, Fig 270a, will be found valuable. A small sheet of brass, or zinc is rolled in such a manner that it will fit between two of the cutting edges of the reamer. If the reamer is inserted with the roll of metal in place it will be evident that the reamer will be forced a trifle from the centre of the bore, and the cutting edges of the reamer opposite the inserted metal roll will remove the metal. Very fine cuts should be taken, and the metal roll placed between different cutting teeth each time that the tool is used. In tapping out nuts it is often desirable to have the thread a little deeper than the standard, or to have the nut a loose fit on the bolt, as is sometimes necesesary when trying to place a machine screw nut on a carriage bolt. In this case a similar roll of metal may be placed between the cutting edges of the tap, as shown at E, Fig. 270a.

SOLDER. Silver solders are generally used for very fine work. They are very fusible, and non-corrosive. Hard spelter is used for steel and iron work, and soft spelter for brass work.

When copper is soldered to iron or zinc, resin should be used, or if chloride of zinc is used for a flux, the joint should be washed afterwards to remove the acid. Un-annealed wires should be soldered at as low a temperature as possible. Solder is always an alloy of other metals. It must not only be more fusible than the metal, or metals to be joined, but it must have some chem-

ical affinity for them. Different kinds of solder are therefore employed for different purposes. It is called either hard or soft, according to its fusing point.

Solders and spelters for use with different metals, and their proportional parts by weight are

Solder for:

Electrician's use—1—Tin, 1—Lead.

Gold—24—Gold, 2—Silver, 1—Copper.

Patinum—1—Copper, 3—Silver.

Plumber's—Hard—1—Lead, 2—Tin. Soft—3—Lead, 1—Tin.

Silver—Hard—1—Copper, 4—Silver. Soft—1—Brass, 2—Silver.

Tin—Hard—2—Tin, 1—Lead. Soft—1—Tin, 1—Lead.

Spelter for:

Fine brass work—8—Copper, 8—Zinc, 1—Silver.

Common brass—1—Copper, 1—Zinc.

Cast iron—4—Copper, 3—Zinc.

Steel—3—Copper, 1—Zinc.

Wrought iron—2—Copper, 1—Zinc.

Side-Slip of Motor-Cars. A wheel with a weight on it when rotating bites into fresh ground as it advances. If the wheel rotates more in proportion than it advances, from any cause, it thereby loosens the particles of dirt beneath it and loses adhesion with the ground immediately under the dirt.

The wheel can now slip sideways as easily

as it can slip forwards, particularly when it has the rounded section slightly flattened, which is the case with pneumatic tires. When traveling straight ahead, and with the motor out of gear, skidding does not usually occur. A slight turn given to the steering wheel checks the speed and introduces a side pressure on both front and rear wheels, due to the machine tending to continue its path in a straight line. Generally this side pressure will not cause skidding. If, however, the motor be suddenly thrown in gear, or the brakes suddenly applied, or, what amounts to the same, a large turn is given the steering wheel, the wheels find themselves either rotating more than in proportion to their advance, or advancing more than in proportion to their rotation. This immediately causes a loss of adhesion, which, once established, causes the car to skid or side-slip.

Spark—Regulation of. Upon the proper use of the sparking device depends the economy of the motor, and in many cases the safety of the driver. On some cars the sparking point on the magneto is fixed, and the autoist controls the car by the throttle only. There are a number of cars in use which employ the battery in connection with separate coils or a single spark system, or a magneto on which the spark can be regulated by the driver. When starting, the spark should be retarded in the case of battery ignition, to prevent backfiring, and slightly advanced to a certain point, depending on the

motor and magneto, in the case of magneto ignition. When it is desired to slow the motor down below the point obtained by throttling only, the spark is likewise retarded. In ordinary running, a position of the spark lever can be found which will give fair average results through a considerable range of speed without changing its position, and this position varies with each motor, and can be found by experience. When a higher rate of speed is desired, the throttle is opened and the spark advanced gradually. If a grade is to be negotiated it should be "rushed" if possible, the throttle being opened full and the spark well advanced until the motor begins to slow down and "knock," when the spark should be retarded to correct this. The autoist should always keep the spark as far advanced as possible, without causing the motor to knock. When accelerating, or retarding, the spark should follow the throttle, the latter always being operated first.

Spark Plugs. The trouble with motors misfiring, is generally due to dirty spark plugs. This is caused by using too much cylinder oil, which, when subjected to the intense heat in the cylinder, turns to carbon. This carbon deposits on the insulated porcelain and the body of the plug, and instead of the current jumping from the point in the body to the point in the porcelain and making a spark, it follows the easiest path, which is the carbon, and does not make a spark at the plug points at all. When

this occurs the motor will misfire. The first thing to do when a motor misfires is to test the spark plug. Turn the motor until the battery circuit is closed. Unscrew the spark plug from the motor, then reconnect the wire to it just the same as it was before. Lay the metal part of the plug body on the flywheel or some other un-

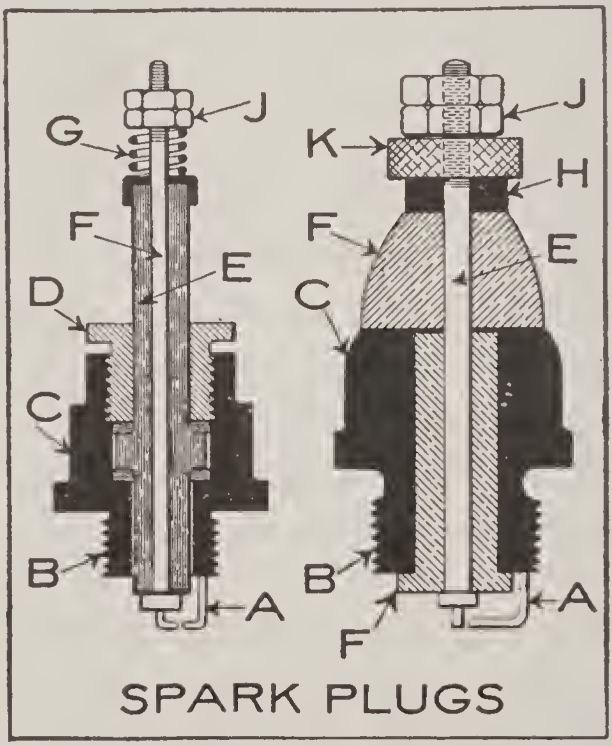


Fig. 271

A—Platinum point.
B—Thread.
C—Plug body.
D—Bushing.
E—Insulated terminal.
F—Porcelain bushing.
G—Expansion spring.
H—Asbestos washer.
J—Lock nuts.
K—Assembly nut.

painted part of the motor, being careful that the metal part of the plug body only touches the motor and that the porcelain part is clear. If the spark jumps in short jerks between the inner end of the porcelain and the interior of the plug body it is sooted, and needs cleaning.

If it jumps at the points as it should do, the trouble is elsewhere; probably at the battery, loose connecting wires, or the vibrator of the coil is not properly adjusted.

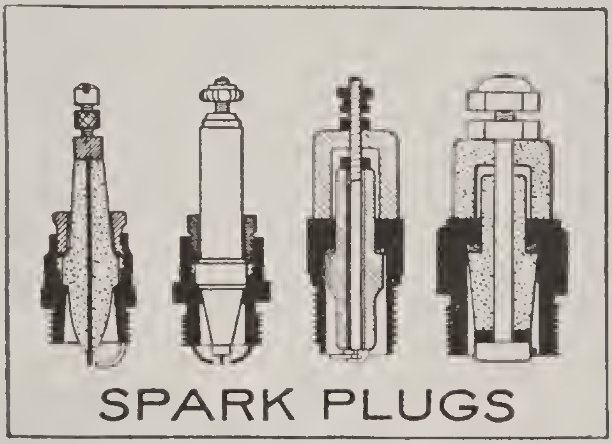


Fig. 272

To clean a spark plug properly use a 50 per cent solution of hydrochloric (muriatic) acid, washing the points of the plug with a tooth brush, occasionally dipping the plug into the

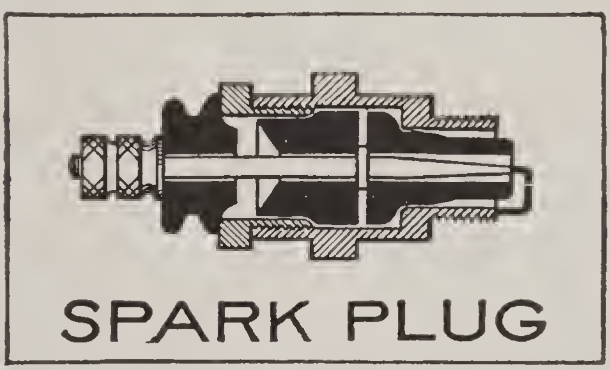


Fig. 273

acid. After cleaning the spark plug in this manner, rinse it in water.

Spark Plugs—Construction of. Two spark plugs are shown in Figure 271, which, while differing radically in their construction, effect the

same purpose, that of producing a spark or arc in the combustion chamber of the motor. The accompanying table and reference to Figure 271, will fully explain the construction of the spark plugs.

Cross-sections of four different forms of spark plugs are shown in Figure 272. All are constructed with a view to make the outside or extraneous path caused by sooting, as long as

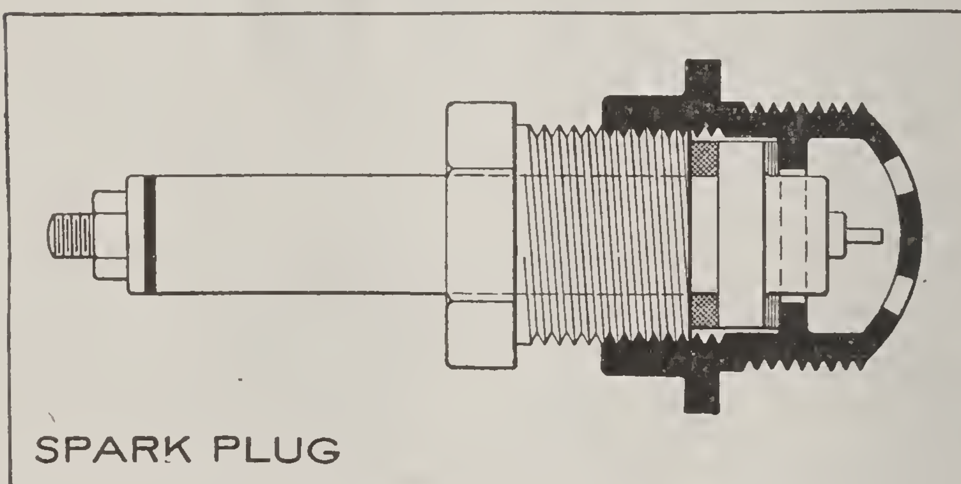


Fig. 274

possible, so as to prevent if possible short-circuiting of the plug from this cause.

Figure 273 shows a form of spark plug in which two extra air-spaces are provided, one between the center rod or terminal and the porcelain bushing and the other between the porcelain bushing and the shell or body of the plug.

The spark plug shown in Figure 274 has a closed chamber around, and over the center insulated rod or terminal; this chamber is a part

of the body of the plug and forms the other terminal of the plug. It acts as a small combustion chamber, and streams of fire are supposed to be thrown from the small openings in the chamber, when the arc or spark occurs therein.

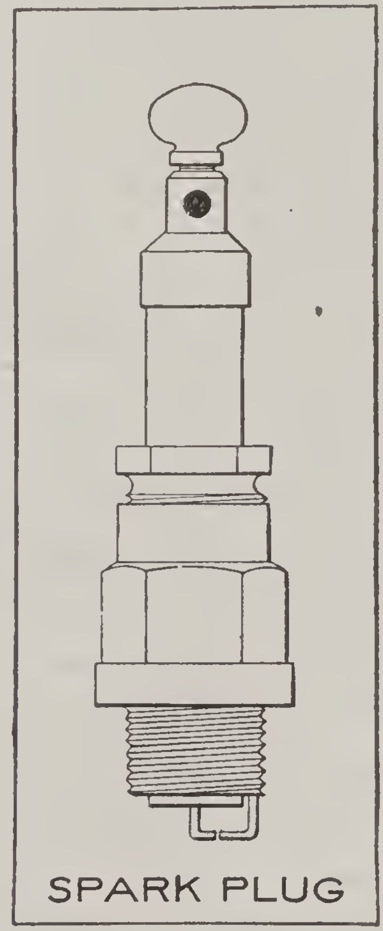


Fig. 275

An exterior view of a form of spark plug in general use is shown in Figure 275.

Spark plugs of American manufacture are made with three different sizes of threads: One-half inch pipe-size, the actual outside diameter of which is .84 of an inch, with 14 threads per

inch. Three-quarters of an inch diameter, with 18 threads per inch, and .7 of an inch diameter, with 17 threads per inch. The last named one is the French, or Metric standard thread.

Spark Gap, Extra. An extra spark gap in the secondary circuit will cause a spark to jump across the points of a fouled plug because the intensity of the voltage of the current is reduced to such an extent that the current will jump across the points in preference to the path of higher resistance formed by the carbon deposit upon the insulation of the spark plug. As the spark plug and the spark gap are in series with each other, it follows that with a single gap—the spark plug alone—the tension of the secondary circuit is about 30,000 volts, while with two gaps the tension at each gap will be only about 15,000 volts. That this statement is true may be shown by an arc light circuit of 500 volts, with five 100-volt lamps in series with each other in the circuit, and which have a potential of 100 volts each, and not 500 volts, as might be supposed. This explanation, therefore, destroys the claim that the use of the extra gap intensifies the arc or spark at the points of the plug. The real advantage of the extra gap is that the reduction of the voltage, instead of its increase, reduces the tendency of the current to arc across the carbon deposit.

The extra spark gap will only be found effective so long as the carbon deposit upon the insulation of the spark plug is small, or mixed

with oil, which increases the resistance of this path. The arcing will continue at the point of the plug until the carbon deposit is rich enough to form a path for the entire volume of the current, when the plug will cease sparking—but the extra spark gap will continue to arc. One advantage of the extra spark gap is that it provides a means of seeing whether the secondary circuit is in working order without removing the plug from the cylinder, and the device should be connected in the circuit by a two-point switch to enable it to be thrown in, and out of the secondary circuit. The use of the extra spark gap will never absolutely remove the necessity for keeping the insulation of the spark plug in good condition and free from soot or oil. As long as the batteries are strong enough to maintain the full voltage of the primary circuit, just so long will the extra spark gap work successfully in the secondary circuit, and when the electromotive force of the batteries falls below the normal point, it will be found necessary to cut out the extra spark gap, to maintain an efficient spark in the combustion chamber of the motor.

Specific Gravity. In the absence of a proper instrument, the specific gravity of gasoline or any other liquid may be obtained as follows:

Weigh a certain quantity of distilled water at 4 degrees Centigrade, or 39 1/3 degrees Fahrenheit.

Weigh the same quantity of gasoline or other liquid under test.

Divide the weight of the liquid by the weight of the water, and this will give the required specific gravity of the liquid.

The specific gravities of various liquids are as follows:

Alcohol at 15° C.	0.794
Acid, nitric	1.217
Acid, sulphuric	1.841
Ether at 15° C.	0.720
Naphtha	0.848
Oil, linseed	0.94
Petroleum	0.878
Gasoline at 15° C.	0.680 to 0.720
Water, sea, at 4°	1.026
Water, pure, at 4°	1.0

Speed, Cyclic Variation of. The cyclic irregularity of any reciprocating-piston motor is defined as the ratio of the difference between the maximum and minimum velocity in any one revolution to the mean velocity. The great difficulty in measuring this ratio is the continual variation in the mean velocity. One system of measurement uses a tuning-fork, which traces a wavy line on a smoked cylinder attached to the motor shaft. Another apparatus consists of a disc attached to the motor shaft, and a flywheel turning freely on the same axis. The disc and flywheel are geared together by a planetary gearing, whose axis, perpendicular to that of the flywheel, carries a pencil point tracing on a rotating drum. The flywheel is turned through the planetary gearing, and takes up the mean speed of the motor. As it is too heavy to follow the cyclic variations in speed of the

disc, these cause the axis of the planetary gearing to move backward and forward round the axis of the disc, and the pencil point therefore traces a periodic curve on the drum. This curve, however, does not give the difference in velocity, but the relative change in position of the disc and flywheel, and the maximum difference in velocity must be calculated from the two steepest tangents to the curve. This apparatus is troublesome in the calculation of results and is not sufficiently sensitive for small irregularities. An apparatus constructed on the principle of the Von Alteneck transmission dynamometer is also used for this purpose, a pulley attached to the motor shaft being connected by a belt to a flywheel, which takes up the mean velocity of the motor. the variations in velocity produce variations in the tension on the two sides of the belt, and an index is arranged to measure these. The elasticity of the belt renders this apparatus unsuitable for any absolute measurements. Another device consists of a heavy cylinder, mounted on an axis fixed to the motor shaft by ball-bearings; the friction in these causes it to take up the mean velocity. A frame fixed to the shaft embraces the cylinder, and carries a pencil point which is free to move along the cylinder. A string attached to the pencil passes over a pulley to a sleeve running free on the axis; if this be held still, the string winds up on it, and pulls the pencil along the cylinder. As the motion of the cylinder is uni-

form, while the pencil follows the irregularities of the motor, the latter traces a curve, from which the cyclic irregularity can be reckoned. This apparatus was found to work well, but was not sufficiently sensitive for small irregularities.

The only method which has been found capable of measuring a very small irregularity is to employ a small independently excited dynamo driven by the motor, and take its curve of volts by means of a Joubert contact-maker and potentiometer. As the volts are proportional to the speed, this gives also the curve of speed of the motor. If there be no irregularities in the dynamo voltage due to its construction, this method is capable of giving very accurate results, but it is troublesome and unsuited for practical work.

Speed of Gasoline Motors. In explosive motors the products of combustion diminish in about the ratio of the increase of speed. The pressures and temperatures at admission and exhaust are variable, and depend on the speed and the mean temperature of the cylinder wall. The compression pressure decreases in proportion to the increase of speed, owing to the diminished volume of mixture at higher speeds. If it were not for this the power of a motor of given bore and stroke would go up in the same proportion as the speed.

An automobile motor differs fundamentally from the stationary form by reason of its being

Fig. 276
Speedometer

required to run at variable speeds. If the valves are well designed, nearly the full volume of gas should be taken in at higher speeds, and the compression will actually improve at higher speeds owing to the diminished time for leakage round the piston-rings. This tends to improve the fuel economy of the motor.

Speedometer. Speedometers for automobile use are made for attachment to the dashboard, and are actuated by means of a flexible shaft and gear attachment to the wheel of the car.

The driving gear consists of a large gear attached to the hub of the wheel, and a small gear carried by a ball-bearing shaft at the end of the flexible cable and supported on the steering knuckle by means of an attaching bracket. By a series of different gears the instruments may be adapted to any standard wheel from 28 to 40 inches in diameter. The change is made by simply removing a cotter pin and substituting a gear of a different diameter and number of teeth.

The ball bearing shaft is provided with a swivel base, which permits the gears to separate, and dislodge any obstacle that may come between the teeth, thereby preventing damage to the gears. The spring in the swivel base operates automatically to bring the gears back into mesh.

The flexible shaft consists of a woven steel wire cable enclosed in a strong brass casing. It is of proper length to permit of the attachment

of the instrument to the driver's side of the dashboard, and to connect with the gears on the front wheel of the car, with allowance for ample play at the gear end to prevent it receiving any strain through the swinging of the wheel in steering.

No lubrication is required, as this is provided for when the instruments are assembled. The flexible shaft casing is partially filled with a composition of graphite and cosmoline, which works down and lubricates the ball-bearing small gear shaft.

Speed is indicated whenever the car is moving; whether forward or backward. Distance is registered cumulatively whether the car goes forward, or backward.

Springs. The length and number of leaves in the springs of motor cars of similar weight and power vary, and without any reason for so doing. The general use of pneumatic tires hides many imperfections in this respect as well as in others. Springs of insufficient strength are a source of great danger, and frequent examination should be given to them. Springs are not necessarily of insufficient strength because they appear to be light. Short springs are not desirable, as they are more liable to break than a longer spring, the deflection per unit of length being greater. Stiffness in short springs is usually avoided by lightness, which is likely to lead to breakage, especially when the hole

for the bolt through the center of the spring is made larger than necessary.

SPRINGS—DIMENSIONS OF. In calculating the dimensions and elastic limit of springs for motor-car use, the elastic limit must be carefully considered with regard to the dead, and maximum loads to be carried by the car. The dead load is the weight of the car when at rest. The maximum load is the greatest weight that can possibly be carried with good spring action. The springs to retain their elasticity should have their ultimate strength far beyond their maximun load capacity.

The old practice of fixing a uniform curvature of the spring leaves frequently leads to breakages due to distortious set up at the spring perch. This tendency is now aborted by making the spring leaves in such a way that the curvature begins at points beyond the spring perch, so that the clamps when they are pulled into tight relation do not straighten out the plates. It is still the custom to use a leather pad on which to rest the springs, because thereby the coefficient of friction becomes that of leather, and creeping tendencies are as a consequence remote. There is also the question of the camber given to the respective spring plates. If the plates are all of the same thickness, they should all be curved to the same radius, for then the extreme fiber strain would be equal in all the plates for every alteration in camber in-

cidental to the service they are placed to perform.

Springs—Testing and Material. The life of a spring is forecast by the maker thereof, almost independently of the quality of the material. If the spring is limber, and it is so placed as to indicate spring play, just at the point of reversals of camber, the life will be shortened. The superior grades of materials will stand this abuse for a comparatively long time, but the dynamic life of steel, like the life of every other animated thing, is limited. Inferior materials, advantageously situated, might last far longer than the superior products working at a disadvantage. The initial camber to give a spring, for a given static camber, is a problem for the springmaker.

Fig. 277 shows three views of a given spring, under the conditions as follows: The spring under static load, indicating the static camber; straightened out under load; in reverse camber, in a testing machine, to the limit before permanent set.

It is worth while to study these three conditions in relation to springs, because they have to do with the life of the spring in service, and the easy riding qualities of the car due to spring action. It might be said in general that the greater the difference between the initial and the static camber, the more pronounced will be the easy riding qualities, and it might be said as well that the greater the initial camber, and

the greater the possible reverse camber, the better will be the life of the springs, especially if we take into account that the spring action in service will be limited between the two points, as represented by the initial camber on the one hand and the condition, which means that the spring leaves will no more than straighten out in actual service. If the service conditions are such as to eliminate any reversal of camber,

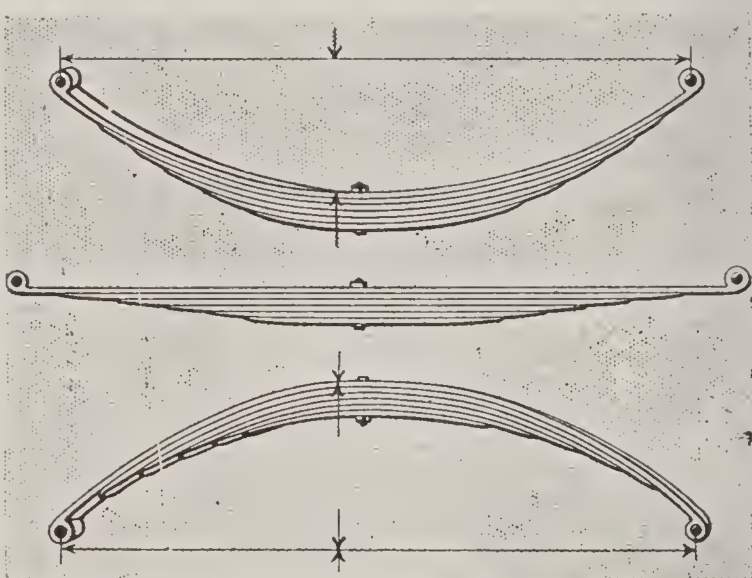


Fig. 277

then it may be said the factor of safety will be represented by the amount of the reverse camber in a testing machine before permanent set.

SPRINGS—CARE OF. Springs should be examined occasionally, and while often overlooked, this seemingly trifling matter has a direct bearing upon the smooth, easy running of the car. Owing to the fact that the springs are exposed to the weather, rust is very likely to occur at

this point, and to this unsuspected corrosion is often due the occasional "squeak." Although many cars are provided with some means for lubricating the friction surfaces, many cars are not so well provided for and when rust makes its appearance along the joints there is a crying need for oil. This may be conveniently applied by placing the jack between spring and frame, and slightly opening the leaves or plates.

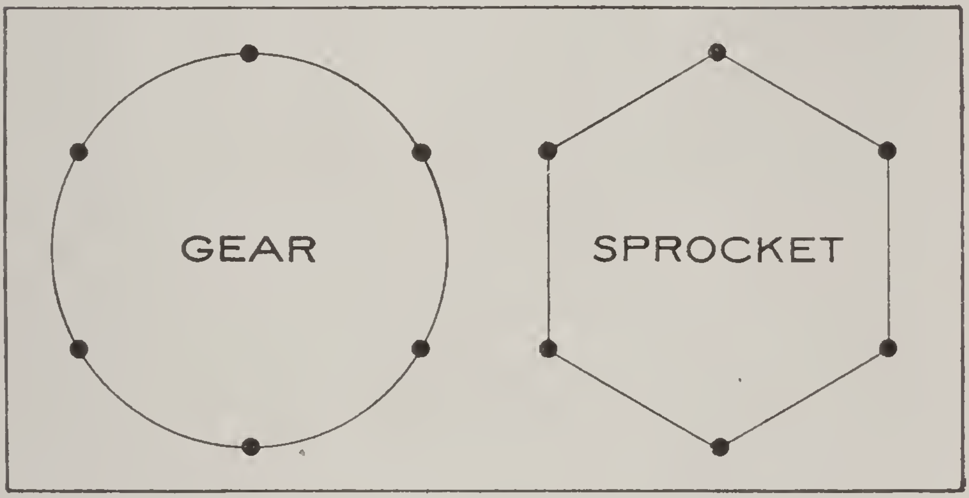


Fig. 278

The toggles and links should also have a little oil occasionally and when about this work it is well to examine the nuts of the clips. These nuts are prone to work loose.

The steering gear should always be given proper care and the levers, pins and joints should be kept free of dirt and well oiled. This is a very important matter, and as neglect may result in a bad accident, injurious to both driver and car, this important mechanism should be given frequent and critical examination.

Sprockets. The circular instead of the linear pitch is often erroneously used in calculating the pitch diameter of a sprocket wheel. Reference to Figure 278 will illustrate the difference between circular and linear pitch, and help to demonstrate the case more clearly. The view at the left of the drawing shows the circular pitch, and the view at the right the linear pitch of a gear or sprocket wheel respectively. If the circular pitch of the gear be one inch and the gear has six teeth as shown, the pitch diameter will be 6×0.3183, which gives 1.91 inches as the pitch diameter. Let the linear pitch of the sprocket be also one inch, and with six teeth as before. In a sprocket having 6 teeth, the radius is equal to the linear pitch, as the figure is composed of six equilateral triangles, and the pitch diameter of the sprocket wheel is consequently 2 inches.

Sprockets, Dimensions of. Table 16 gives the pitch diameters of sprockets for roller chain of 1 inch, 1¼ inch and 1½ inch pitch, with 7 to 28 teeth. The outside diameters may be found by adding the diameter of the roller to the pitch diameter of the sprocket.

Sprocket Chain Lubrication. The best lubricant for sprocket chains is a constant puzzle. If oil is used it is absorbed by the dust which settles on the chain. If tallow or other animal grease is employed it is pushed away from the bearing surfaces, and the latter get dry. The ideal lubricant would seem to be something be-

TABLE 16.

DIMENSIONS OF SPROCKETS FOR ROLLER CHAIN.

Number of Teeth in Sprocket.	1 Inch Pitch. Pitch Dia.	1¼ Inch Pitch. Pitch Dia.	1½ Inch Pitch. Pitch Dia.
7	2.31	2.88	3.46
8	2.61	3.27	3.92
9	2.92	3.65	4.38
10	3.24	4.04	4.85
11	3.54	4.44	5.33
12	3.86	4.83	5.79
13	4.18	5.22	6.27
14	4.50	5.62	6.75
15	4.81	6.01	7.22
16	5.12	6.41	7.69
18	5.76	6.41	8.64
20	6.39	7.99	9.59
22	7.03	8.79	10.55
24	7.66	9.58	11.49
26	8.31	10.38	12.44
28	8.95	11.19	13.42

tween an oil and a grease, too thick to be drawn out by absorption, yet soft enough and clinging enough to stay in the rollers. This mission is approximately fulfilled by a mineral grease, such as non-fluid oil, or Keystone grease, which are not affected by moderate changes of temperature, and have the clinging quality which animal greases lack. The makers of these greases, however, do not recommend heating them, and they cannot be introduced into the links and rollers of the chains, except by rendering them temporarily more fluid than they are desired to be in service. A very good lubricant for this purpose is made by dissolving Keystone grease in gear case oil, in amounts sufficient to produce a viscous fluid at the boiling

point, which thickened when cold, and would just barely flow. A fairly liberal quantity of graphite was added, about half a cupful to three quarts of dope, and the chains after cleaning were boiled for half an hour or longer in the mixture to enable it to penetrate thoroughly.

Starting a Motor. The most important point about starting a gasoline motor is to ascertain if the cock in the supply pipe leading from the gasoline tank is open. Failure to do this has caused the display of more temper, profanity and anxiety than any other detail, except that of forgetting to close the switch before cranking the motor. Another point is to see that the tank has been previously filled with gasoline.

Next flush the carbureter to see if the gasoline flows from the tank, then give the motor one or two turns by means of the starting-crank and with the compression-release cock (if any) open. If a mechanical feed, or splash lubrication is used, there will be no necessity to look after the lubrication, but if a gravity oil feed is used, do not forget to turn on the oil before starting the motor.

Never forget to retard the ignition before starting the motor. A back fire will result if this precaution is neglected, and a nasty blow, or even a broken wrist or arm may be the result. The proper way to avoid this trouble is to have the ignition lever spring-controlled so that the ignition is always retarded when the motor is not running.

If the motor refuses to start, the trouble may be due to oil or grease on the spark plug points; this may be remedied without removing the plug, by disconnecting the secondary wire from the plug, and placing it near the terminal, so as to allow an external and visible spark to occur. Once the motor is started, the oil gets burned up by the heat, so that ignition will continue after a permanent connection of the secondary wire has been made. Generally it is necessary to stop the motor, or at least the spark, to facilitate re-connecting the wire without receiving a shock, but if the motor is hot it will re-start easily. This is merely a temporary adoption of the extra spark gap.

Sometimes the motor will start readily, but dense smoke having a strong odor will issue from the muffler. This may be an indication that the mixture is too rich, although it is frequently due to an excess of lubricating oil in the cylinder. To correct the mixture, more air should be admitted to the carbureter.

Failure of the motor to start is more often occasioned by too weak, than by too rich a mixture. The first thing to do, if regulating the air does not correct it, is to ascertain if the gasoline pipe is free from obstruction. This pipe is not large, and is more or less crooked. A partial stoppage of the pipe will therefore result in a too weak mixtuer.

Water in the carbureter is not an infrequent cause of the motor failing to start. All gaso-

line contains more or less water, which, being heavier than the gasoline, settles to the bottom of the supply tank, and finds its way to the carbureter. If the pet-cock at the bottom of the carbureter be opened, the water—which will have collected in the lowest part of the carbureter—will pass out with the gasoline.

Other causes of failure to start on the spark may be (1) leaky valves, (2) sticking of piston rings, (3) a leak around the cylinder or spark plug, (4) weak batteries. For valves or piston rings put two or three tablespoonsful of kerosene into each cylinder, then close all compression cocks and turn the motor over very slowly fifteen or twenty times, so that the compression will force the kerosene down past the piston rings. Then let the car stand for several hours. It might be necessary to repeat this operation for two or three nights. Then have the valves all carefully ground in, and see that when the valves are closed there exists between the pushrods and valve stems a space equal to at least the thickness of an ordinary visiting card. After securely replacing the cylinder and spark plugs, test them by applying a little oil or soapy water around the edges while the motor is being turned over. Having secured good compression, overhaul the ignition system; see that the batteries are fully charged, coils properly adjusted and timing correct. A storage battery, when fully charged, should show a voltage of 2.2 volts per cell, making 6.6 for a 6-volt

battery. This may be used until the voltage drops to 5 volts, when it is advisable to have the battery re-charged. As to the timing of the spark, adjust it so that when the control lever is fully retarded, the spark will occur when the piston is about ¾ or 1 inch down on the explosion stroke. Now, if the carbureter adjustments are correct, the motor should start on compression. When starting this way is desired, the operator should turn off the current, then open the throttle wide. It is not necessary to race the motor, then switch off the current; the cylinders will get a better charge if just three or four slow revolutions are made after the ignition is cut off.

Starting—Hard. It often happens that an engine after having been in operation for several miles and then stopped for a few minutes, cannot be started again until cooled by allowing a quantity of cold water to pass through the radiator for several minutes.

The trouble in many instances is due to the overheating of the cylinders to such a degree that the pistons are upon the point of seizing, in fact do seize for the time being, when the car is stopped with the water in the radiator at the boiling point. This would indicate insufficient water circulation, and the remedy is to put a larger driving, and a smaller driven gear on the pump, and thus increase its speed—this will cause the water to circulate at a higher speed, and thus carry away more heat, since the quan-

tity of heat carried away varies directly with the amount of water circulated.

In a set of gears of 6 pitch and 18 teeth, changing the driver to 21 teeth and the driven gear to 15 teeth will leave the center to center distance unchanged at 3 inches, and will increase the pump speed by 40 per cent. If this is not sufficient a later change to a driver of 24 teeth, and a driven gear of 12 teeth will also leave the center to center distance unchanged, but will change the speed, increasing it 100 per cent over the first arrangement and 43 per cent over the second method of gearing.

Driving the pump faster will cure the trouble unless the pipes are clogged up. In fact, it would be well to go to the trouble of examining these before making the other change, that is changing the speed of the pump by altering the gearing.

Steam Automobiles. There are several advantages possessed by steam motors as compared to explosive motors. For instance, speed variations are obtained without the shifting of gears, the speed being regulated by the throttle. The steam motor will start without cranking, and in operation it is noiseless. Also it is better for climbing hills.

Principles of the Steam Machine. In all steam machines there must be a gasoline burner, a boiler, a steam engine, usually compound, a condenser, water pump, gasoline pump and a pilot lamp.

The water in the boiler is converted into steam at a high pressure by the heat from the gasoline burner. It is then conducted to the engine, where it performs its work in the steam cylinder, being used expansively whenever conditions permit. From the engine the steam is generally conducted into a condenser, which forms the front end of the car. After being partially condensed, the water flows into the water tank. There is a large fan behind the condenser, which aids the circulation of air between the tubes, thus increasing the efficiency of condensation.

There is generally a feed water heater used, located in the exhaust pipe leading to the condenser. The water, on its way from the pumps to the generator, passes through this heater and absorbs a certain amount of heat from the exhaust steam, after which it enters the boiler or generator.

Fuel is supplied to the burner from a gasoline tank, which is generally equipped with a level indicator. The fuel is supplied to the burner under pressure, which is maintained by the air pump attached to the engine. The fuel passes through a vaporizer and then enters the burner, where it mixes with the air and burns.

A pilot light is used for the two-fold function of heating the vaporizer, and lighting the burner, as fuel is generally only intermittently supplied to the burner, depending upon the

steam pressure, which automatically regulates the fuel supply.

The steam engine, which is used on steam automobiles, differs materially from the gasoline engine. A steam engine is double acting; that is, the steam acts on the piston during each stroke, so that there is always a pressure on one side of the piston which is available for work. For this reason the engine can never be stalled so long as there is pressure in the boiler. A steam auto engine is never made in four or six cylinders, like a gasoline engine, but is generally made with two cylinders, with cranks set at 90 degrees with each other, so that there is always one crank which is in an effective turning position.

There are two general types of steam engines in use on automobiles, two-cylinder simple engines, and two-cylinder compound engines. In the two-cylinder simple engine, such as used on Stanley steamers, each cylinder obtains its steam supply from the boiler, independent of each other. In the two-cylinder compound, such as used on the White, and Lane cars, there is what is called a high pressure cylinder, and the steam, after having been used in that cylinder, is used in the lower-pressure cylinder, which is always larger than the high-pressure cylinder, after which it is exhausted into the condenser. In the cases where simple engines are used, it is not usual to use a condenser for condensing the exhaust steam.

VALVE GEAR. There are two types of valve gear in general use on steam automobile engines, which regulate the cut-off and allow the engine to reverse. These are the Stephenson link motion, and the Joy valve gear. Up until 1909, the White steamer used the Stephenson link motion, but since that time the Joy valve

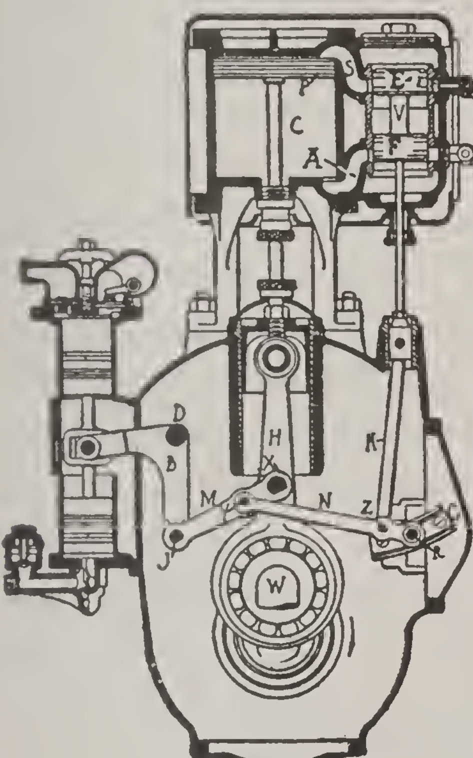


Fig. 279

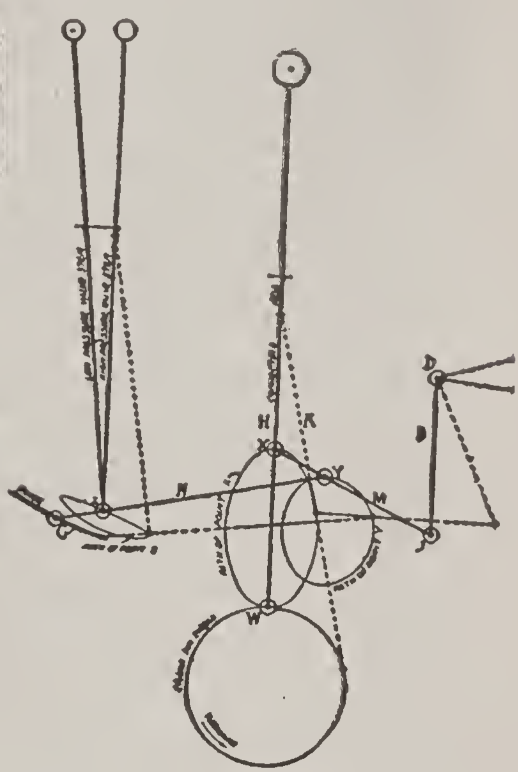


Fig. 280

gear has been employed. The Lane steamers use the Stephenson link, while the Stanley steamers use what might be classed as a direct valve motion, as it does not use the accepted Stephenson valve gear except when it is reversed. The forward eccentric is held in forward motion by spring pressure. For reversing a pedal button overcomes this pressure and throws into use the reverse eccentric.

Joy Valve Gear. This type of valve gear is now used on White steamers in place of the Stephenson link. The arrangements of the different parts of the engine are shown in the accompanying diagram, Fig. 279, in which P is the low-pressure steam piston shown at the top of the stroke, the high-pressure cylinder not appearing in the illustration. Steam is admitted to the upper, and also to the lower side of piston P by the piston valve V which has a reciprocating motion. The length of travel of valve V can be varied, and the quantity of steam admitted to the cylinder is thus regulated to suit the demand for power. The passage of the steam to the cylinder C is through ports S for the down stroke, and A for the up stroke, these ports being opened and closed alternately by valve V. This valve is what is termed inside admission, the steam entering ports S and A from between heads E and F of the valve, and exhausting around the outside of same. Valve V receives its motion from the connecting rod H, by means of the valve gear as follows: One end of link M hinges to H, and the other end to a bell crank B pivoted at point D which is stationary. A link N hinges to link M, at one end, while its opposite end carries a roller R running in a guide G. To link N near its outer end is connected the rod K for operating the valve. The length of travel of valve V is varied by tilting the guide G. With this guide tilted so that its outer end is lowered, giving it a hori-

zontal position, there would be a minimum valve travel, and conversely if the guide be brought to a greater tilt the result will be a greater valve travel.

Reversal of the motor is also accomplished by tilting guide G. A line diagram, Fig. 280, shows the action of the Joy valve gear. The heavy lines show the system in one position, and the dotted lines in another position. The lower circle shows the path of the crank pin W. The ellipse immediately above it shows the path of point X, which is the point where link M is attached to the connecting rod H. The flattened ellipse to the right is the path of point Y, the connection of link N, and having a direct bearing on the movement of the valve. The flat oval at the left shows the path of travel of point Z which is the lower end of the valve connecting rod. This oval gives a definite idea as to the movement of the valve. According as the guide is tilted, or lowered to give different degrees of cut off, this ellipse will tilt, or reach the horizontal. The heavy lines show the relative positions of all parts, when the piston is at its highest point as shown in Fig. 279, and the dotted lines indicate a point 90 degrees in advance of this. In these engines the low pressure valve is 2½ inches in diameter, and the high pressure valve is 1¼ inches in diameter. Each valve is given 1/32 inch lead, and the maximum travel is 1¼ inch.

THE TOLEDO STEAM MOTOR. Fig. 281 is a

semi-sectional view of the Toledo steam motor. It is pivoted to the car body by a ball joint at the top, and is also held in position by a distance rod passing to the back axle.

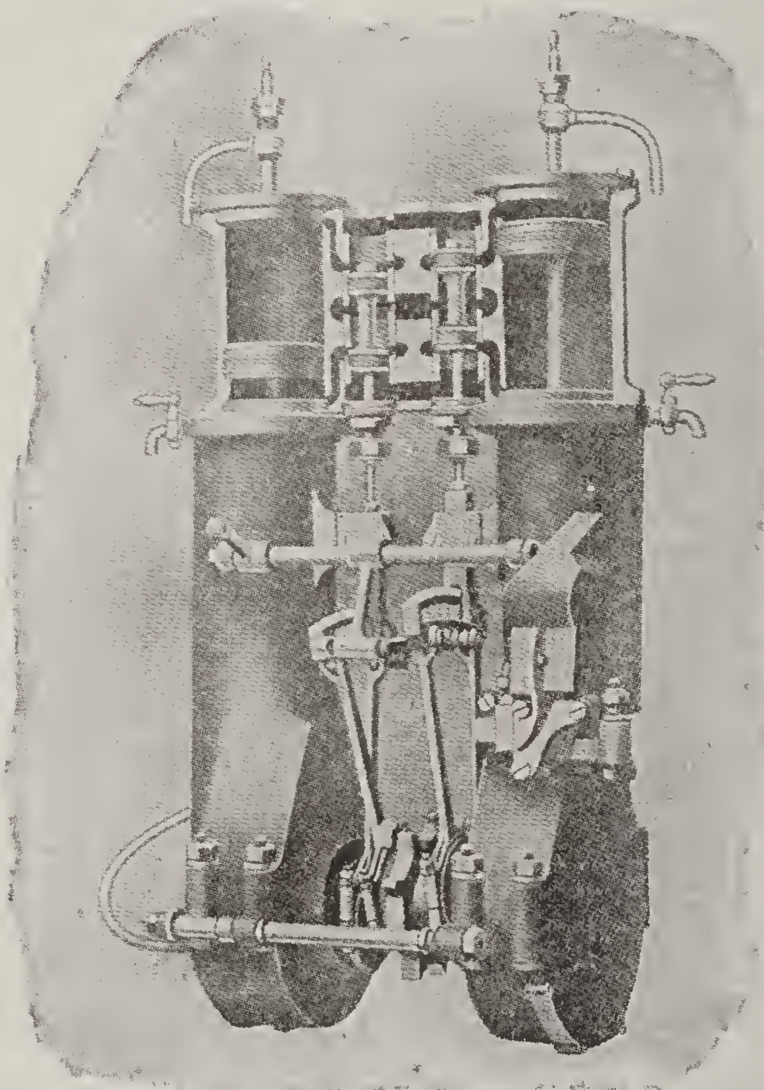


Fig. 281
Toledo Steam Motor

It has two vertical cylinders, double acting, and high pressure. The valves are of the piston type as shown. The cylinder bore is 3 inches, length of stroke 4 inches. The valves are operated by the Stephenson link valve gear.

The crank chambers entirely enclose the connecting rods and cranks, the pins being lubricated by the splash system. The cylinders are lubricated automatically from a steam-pressure tank of a capacity sufficient for 150 miles. The cross-heads for the two cylinders are connected

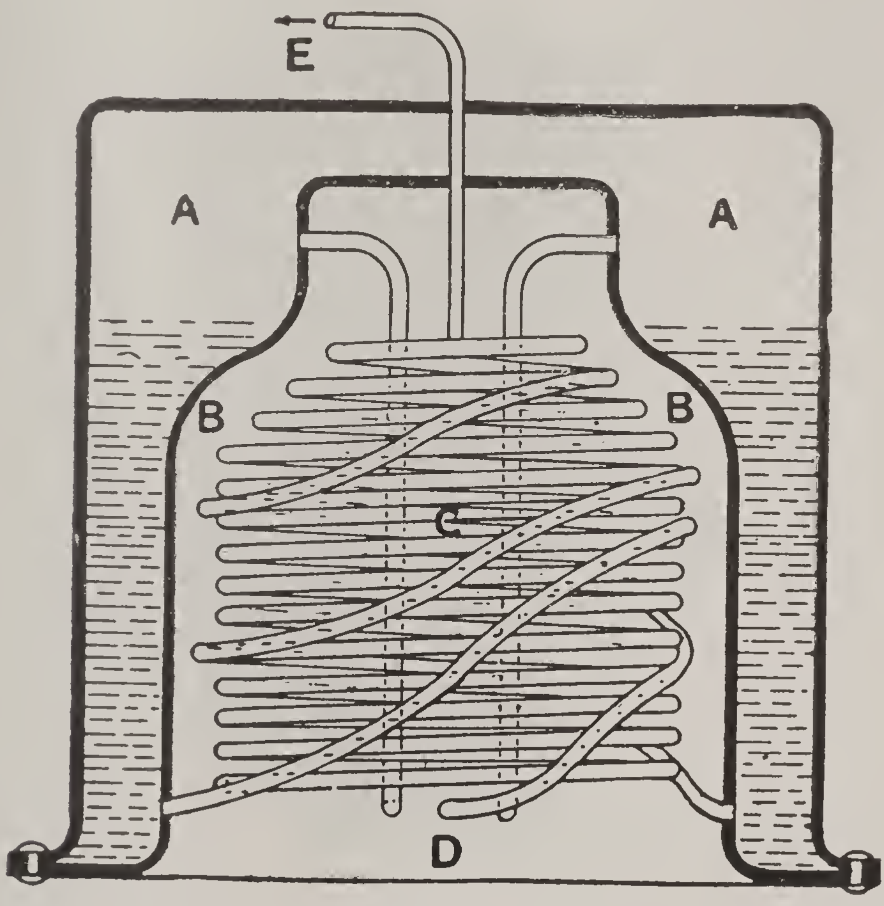


Fig. 282
Toledo Boiler

with the plungers of two pumps fitted at the sides of the motor and enclosed in dust-proof casings. One pump is for the boiler feed water, and the other maintains an air pressure in the fuel tank. Relief cocks in the cylinders allow any condensed water to escape at starting.

The builders claim that this motor develops one horsepower per hour for each 24 pounds of steam consumption.

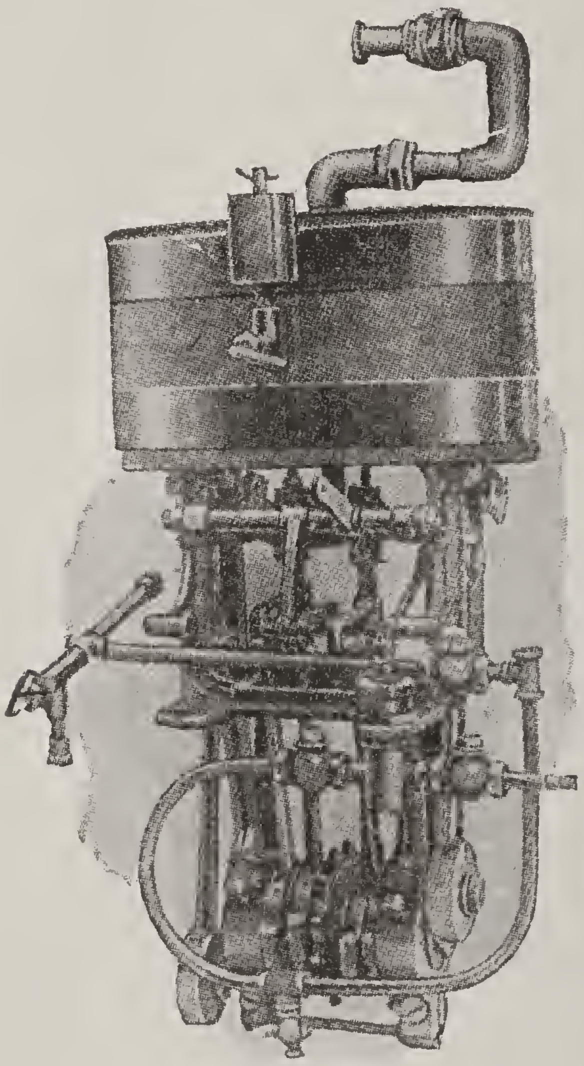


Fig. 283
Weston Steam Motor

Toledo Boiler. The Toledo water-tube boiler, Fig. 282, has one shell B within another, the chamber, A, between them forming an annular water space. Within the inner shell several lengths of weldless steel tube are wound

spirally to form a central coil C; the ends of the tubes are fitted into the inner shell at top and bottom. The burner flame at D passes up between these tubes and causes rapid circulation, which prevents any deposit forming except at the bottom of the annular space. There are

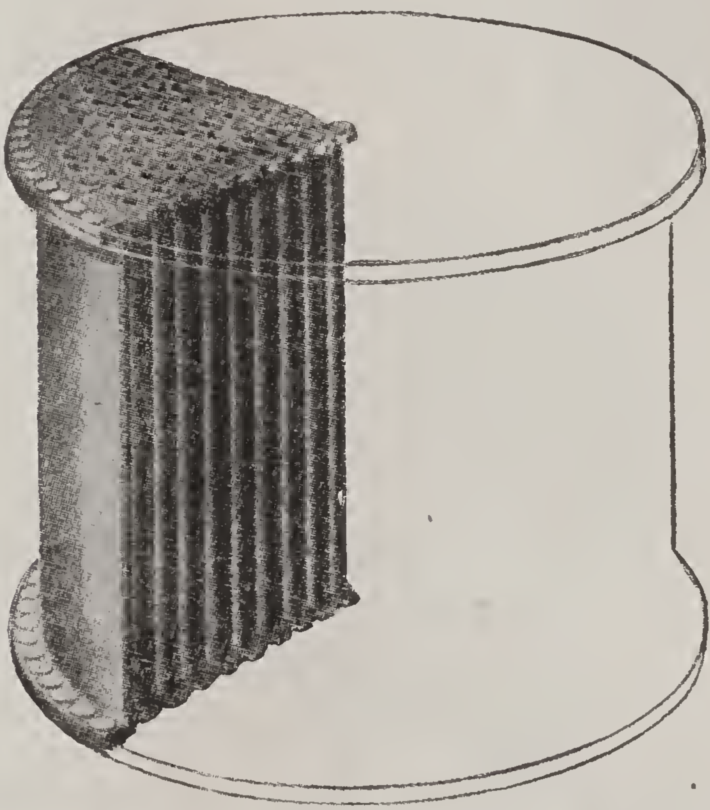


Fig. 284
Weston Boiler

small dams or scoops at the mouths of the tubes, where they open into the annular water space. The steam is taken from space A, superheated within the coil C, and passed to the motor through pipe E. The working pressure is from 200 to 250 pounds per sq. in., and the boiler is tested to 600 pounds per sq. in.

Weston Steam Motor. Fig. 283 shows a 6 H. P. double-acting two-cylinder Weston motor with the customary link motion. The frames are of phosphor-bronze, and the majority of the bearings are of the ball type.

The eccentrics and driving sprocket form a single drop forging, and the two cranks which fit into this piece at the ends are securely pinned in place.

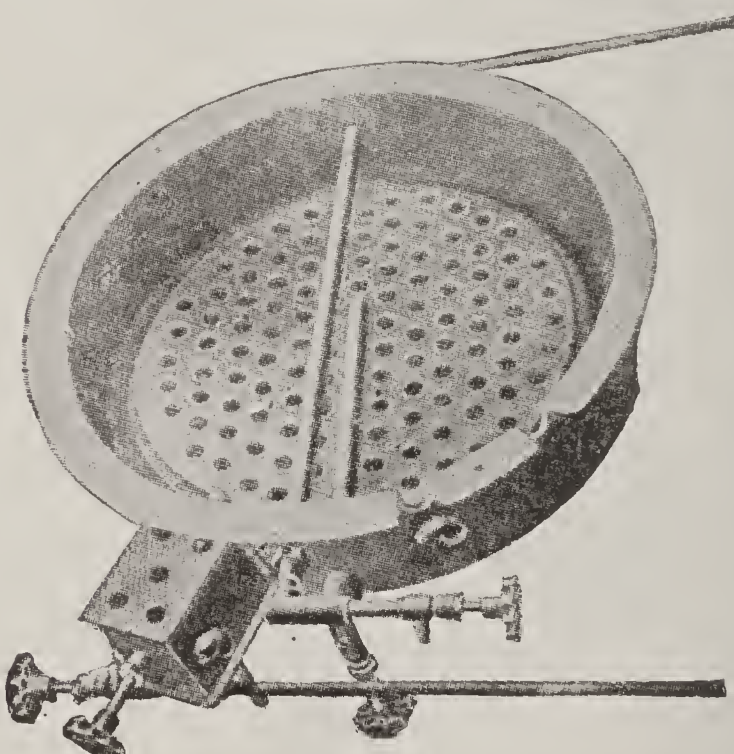


Fig. 285
Weston Burner

Weston Boiler. The Weston boiler, Fig. 284, is an extremely simple, well made fire-tube boiler. The cylindrical shell, and tubes are of copper, the tubes being secured into steel end plates. Its heating surface is 45 sq. ft., and is tested to a cold water pressure of 600 pounds per sq. in. A safety valve blows off at a pres-

sure of 225 pounds per sq. in. The burner, Fig. 285, is of more particular interest. Two separate supply pipes lead to it, one feeding the pilot light, which heats the vaporizer tube, and the other leading through the vaporizer to the main burner. The driver regulates the fuel feed. For lighting the burner a small quantity of gasoline is allowed to flow into the receptacle beneath the pilot lamp, which resembles an ordinary plumber's blow lamp. The gasoline is lighted, and as soon as the lamp is heated sufficiently, gasoline is fed to it at a constant rate. The flame of the pilot lamp plays upon the vaporizing tube which passes diagonally across, above the burner. Its end farthest from the pilot lamp is heated by the burner itself. A steel cable inside the tube acts as a distributing baffle for the main fuel feed, and increases the heating surface of the vaporizer.

White Steam Generator. In this system the inter-relationship of water, gasoline and steam is both interesting and novel, and thus far, as demonstrated by daily use, has proven to be entirely satisfactory. The principles upon which it acts are: (a) the water carried in the tank must be delivered in proper quantities to the generator, where it is flashed into steam; (b) this highly superheated steam must be generated as fast as used, because no extra volume of it is carried as in the ordinary steam boiler; (c) the gasoline must be delivered in such quantity to the burner as to insure the maintenance

of the proper degree of heat to generate sufficient steam. All this is accomplished by causing the steam pressure to control the supply of water delivered to the generator, and the water pressure to control the gasoline supply to burner. The steam temperature also influences the water supply, as will be seen by the following description, as published in Motor Age.

"The system is diagrammatically illustrated in Fig. 286. In the water system, the water must go from the water tank to the generator; it is drawn from the tank by two positively-driven pumps P, on the engine, through pipe P1. From each pump it follows the piping P2 to the flow motor, whose workings will be considered later; thence to the feed water heater which is simply a coil of pipe at the engine to heat the water before it goes through pipe P3 to the generator. The pumps P are constantly working when the engine is running, always pumping the same amount of water per minute, at the same engine speed; but the reader will realize that sometimes more steam is needed than at others at the same engine speed, and consequently more water will be needed. The first device for regulating the flow of water is the water regulator into which the water flows by pipe P4. Its entrance to the regulator is governed by a valve, which only opens when the steam pressure gets above the 600-pound mark. This opening is accomplished by steam pressure through the pipe S3, acting on a dia-

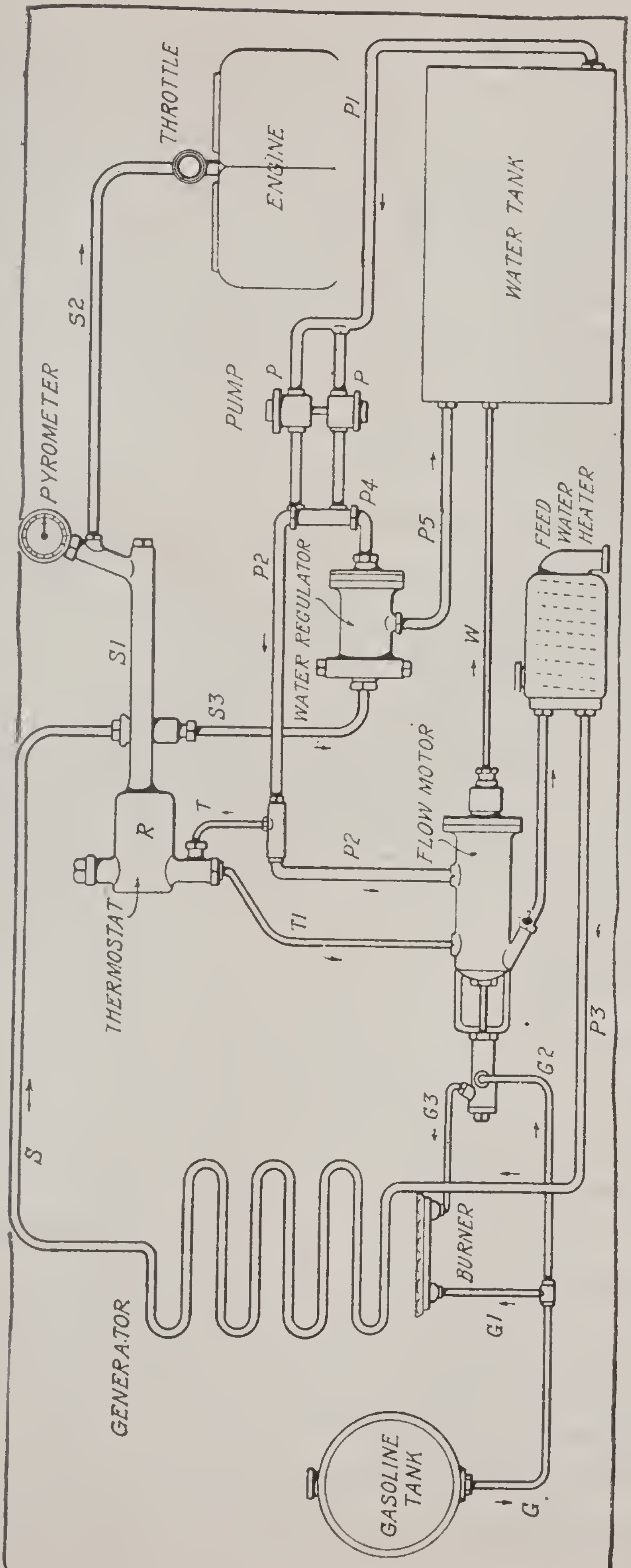


Fig. 286
Diagram Illustrating System of Gasoline, Water and Steam in White Cars

phragm which opens the valve, letting the water enter the regulator, and escape through the pipe P5 back to the water tank, so that when there is 600 pounds pressure, which is the working figure, the water delivered by the pumps P does not follow the course through pipe P2, to the generator, but is by-passed through pipes P4 and P5 to the water tank. This is the first feature of the water control.

"With the water delivered to the generator gasoline must be delivered also in order to have heat to generate steam. The gasoline is carried under pressure in the tank at the rear of the chassis, and starts on its trip to the burner through pipe G, the first branch G1 goes to the pilot light which must be kept burning all the time the car is running. This pilot light is a small flame whose heat does not enter into changing the water into steam, but serves solely to light the gasoline vapor in the burner, as it must be realized the burner flame is out 1 minute, and on the next, according to the amount of steam required; the automatics of the system shut off and turn on the burner according to the demand, but the pilot light always burns to serve as the match for ignition. The gasoline, which goes to generate steam, follows pipe G2, into the pointed end of the flow motor, where its flow is regulated by a valve opened and closed according to the water pressure, and finally reaches the burner through the pipe G3. Some gasoline controlling valves are not shown in

the diagram, the object of this diagram being merely to show the elements of the system.

Having the water and gasoline at the generator, steam is the product and its course to the engine is next in order. It follows the main pipe S, which, before reaching the engine, has an enlarged section S1 which contains the cop-

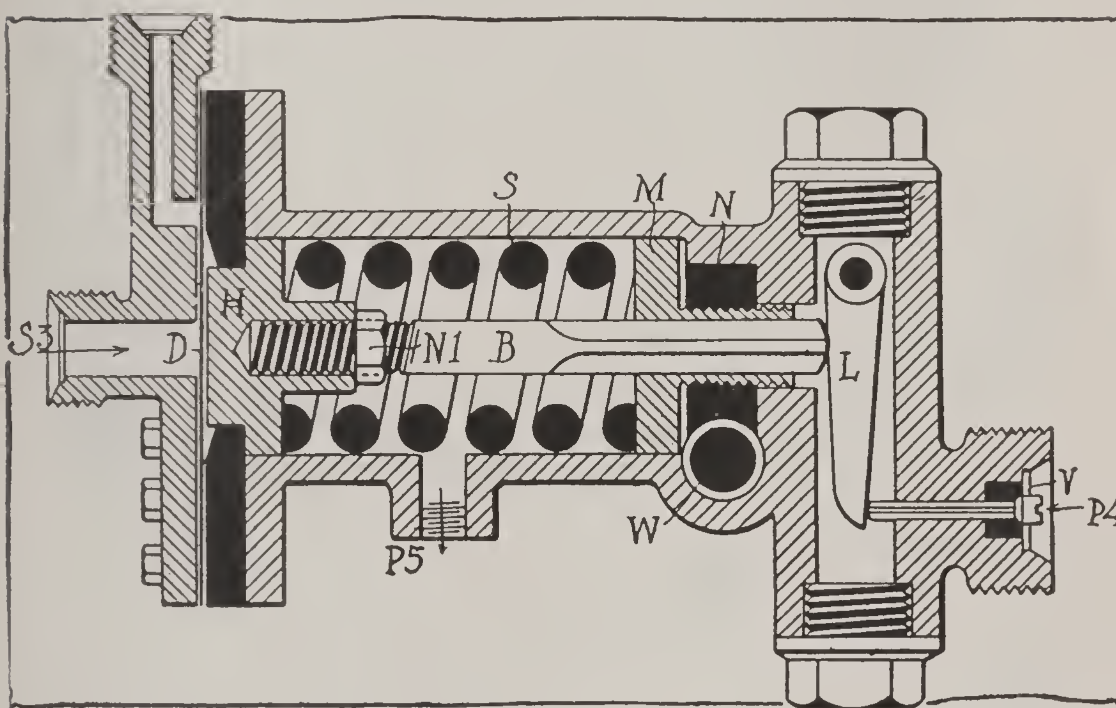


Fig. 287
Water Regulator in White Cars

per rod of the thermostat, and then reaches the engine through the continuation pipe S2. There is a branch S3 for conveying steam pressure to the water regulator. The pyrometer indicates the temperature of the steam. In brief, the action of the thermostat is to govern an additional supply of water to the generator. When the temperature of the steam gets too high, it means

more water is needed in the generator, and the thermostat delivers this extra water supply as follows: The higher temperature of the steam expands, or lengthens a rod, which through a rocker arm opens a valve, allowing water from the main supply pipe to flow through the pipe T and thence through pipe T1 into the flow motor. As soon as the steam temperature drops to nor-

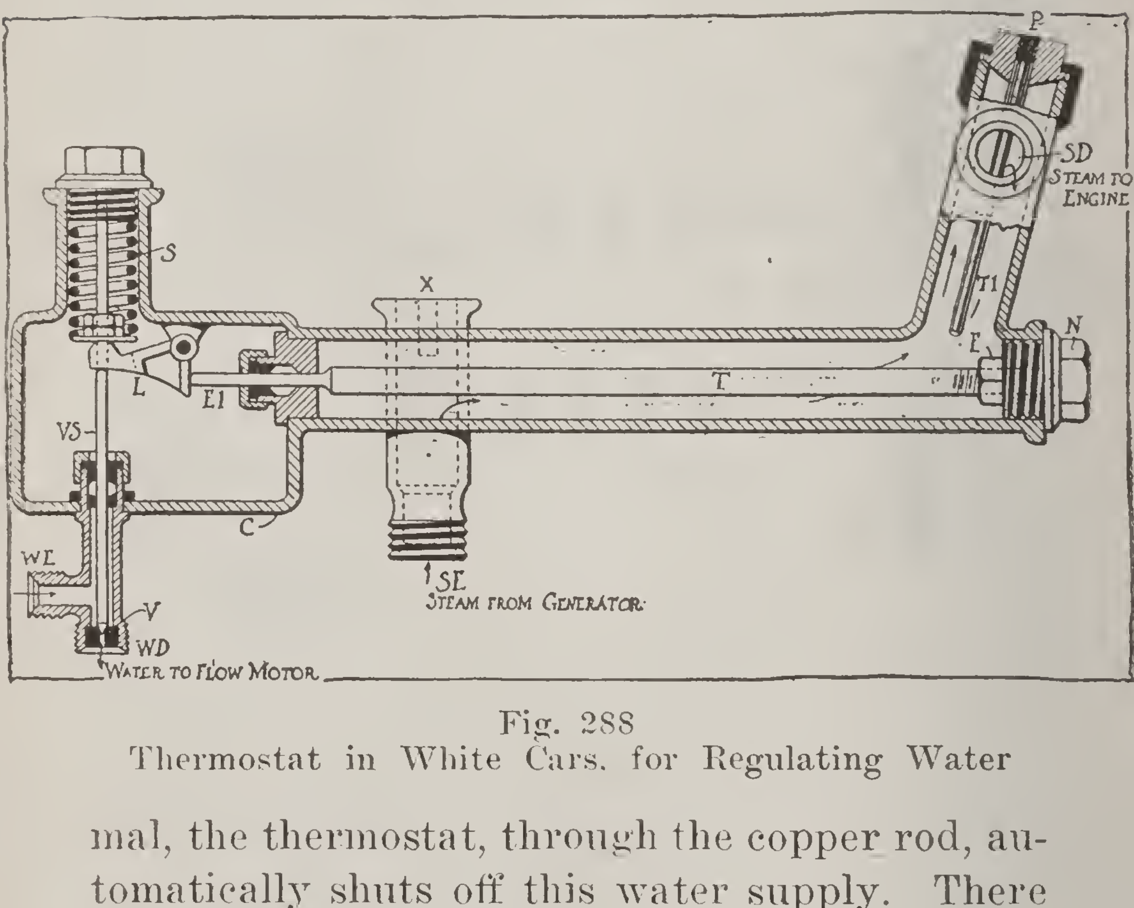


Fig. 288
Thermostat in White Cars. for Regulating Water

mal, the thermostat, through the copper rod, automatically shuts off this water supply. There is a further control on the water by the flow motor, which, at a certain time, by-passes through the pipe W, water to the tank. The exact operation and construction of the water regulator, the thermostat, and the flow motor follow:

The water regulator, Fig. 287, has as its most essential feature, a triple diaphragm D against one side of which the steam from the engine bears through the pipe S3. On the other side of the diaphragm is a metal member H adjustably secured to the shaft B, and which member at its opposite end bears up against the lever L, the lower end of which contacts with the stem of the valve V. This valve V regulates the water entrance P4 from the pumps, so that when the valve opens water enters and escapes by way of pipe P5 to the water tank. The coil spring S normally holds the piece H against the diaphragm so that the valve V closes. However, when the steam pressure through S3 exceeds a certain figure, the diaphragm is forced to the right compressing the spring S and opening the valve V, allowing the water to flow as mentioned, the water, as illustrated in Fig. 286, being by-passed to the water tank.

The construction of the flow motor and its operation is more intricate but equally automatic. It consists of three parts, Fig. 289: The right section W in which the water control is adjusted; the small end portion G at the left which controls the gasoline flow to the burner; and the connective portion C. Water enters direct from the pumps through the port WE, and escapes through the latter opening WD, to the feed water heater. Its control of the water is by means of the piston P which, when moved leftward by water pressure, uncovers groove G,

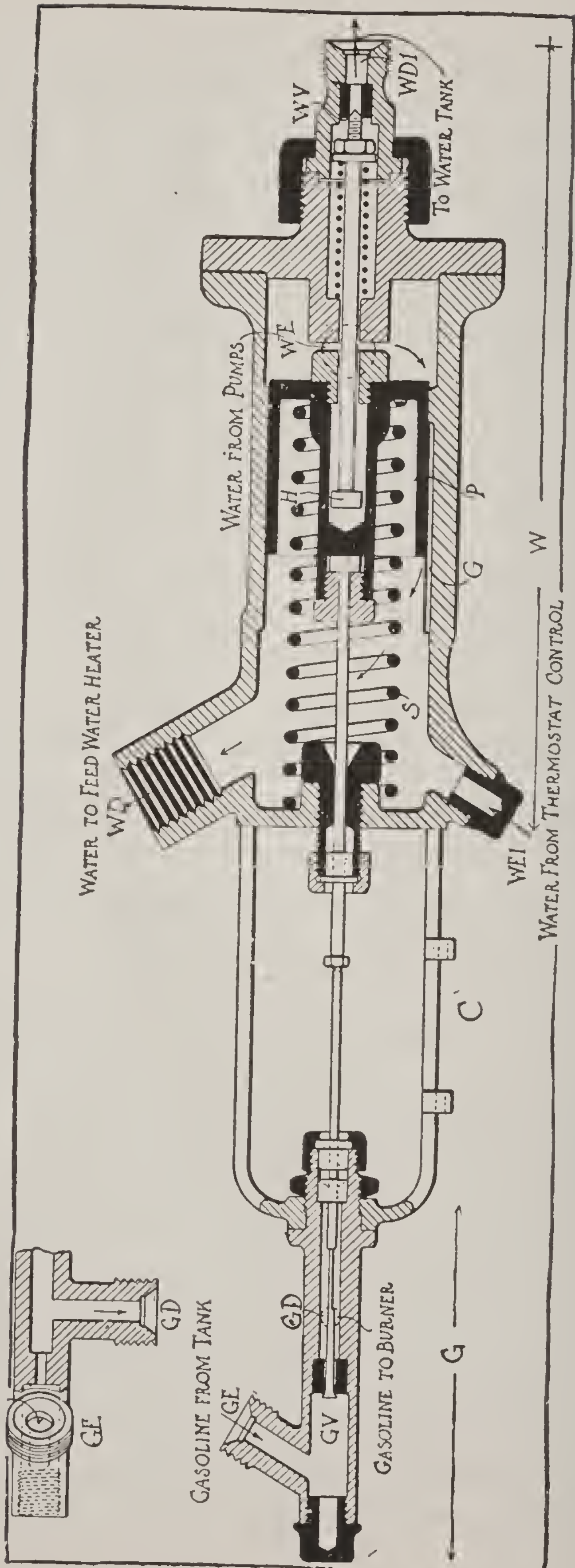


Fig. 289
Flow Motor in White Cars for Regulating Gasoline and Water

thus allowing the water to pass it and escape through the connections WD. This piston P is in rigid conection with the gasoline controlling valve GV, in the left compartment of the flow motor, so that valve GV also moves leftward, permitting gasoline which enters from the gasoline tank through the opening GE to escape to the burner through another opening GD. The faster the engine runs the faster the pumps pump water, and the greater the water pressure against piston P the further will it be moved leftward against the spring S, the more water will pass it, and, proportionately, the more gasoline will go to the burner. When piston P has traveled leftward a certain distance it contacts with the end H, which is on the stem of the valve WV, and a further leftward movement of piston P opens the water valve, which allows the water to escape through opening WD1, and thence to the water tank. This precautionary valve opens only when too much water is being pumped, and allows a portion to flow back to the tank. The entrance WE1 is for water admitted from the thermostat control.

The operation of the thermostat is shown in Fig. 288. Steam enters through SE from the generator and departs through opening SD to the engine. In its passage it contacts with a copper rod T anchored rigidly at one end E in the casing, and at the end E1 bearing upon a lever L which bears upon a collar on the valve stem VS. The high temperature of the steam

lengthens rod T which, through lever L lifts valve V from its seat, and allows water from the pumps to enter WE and escape through

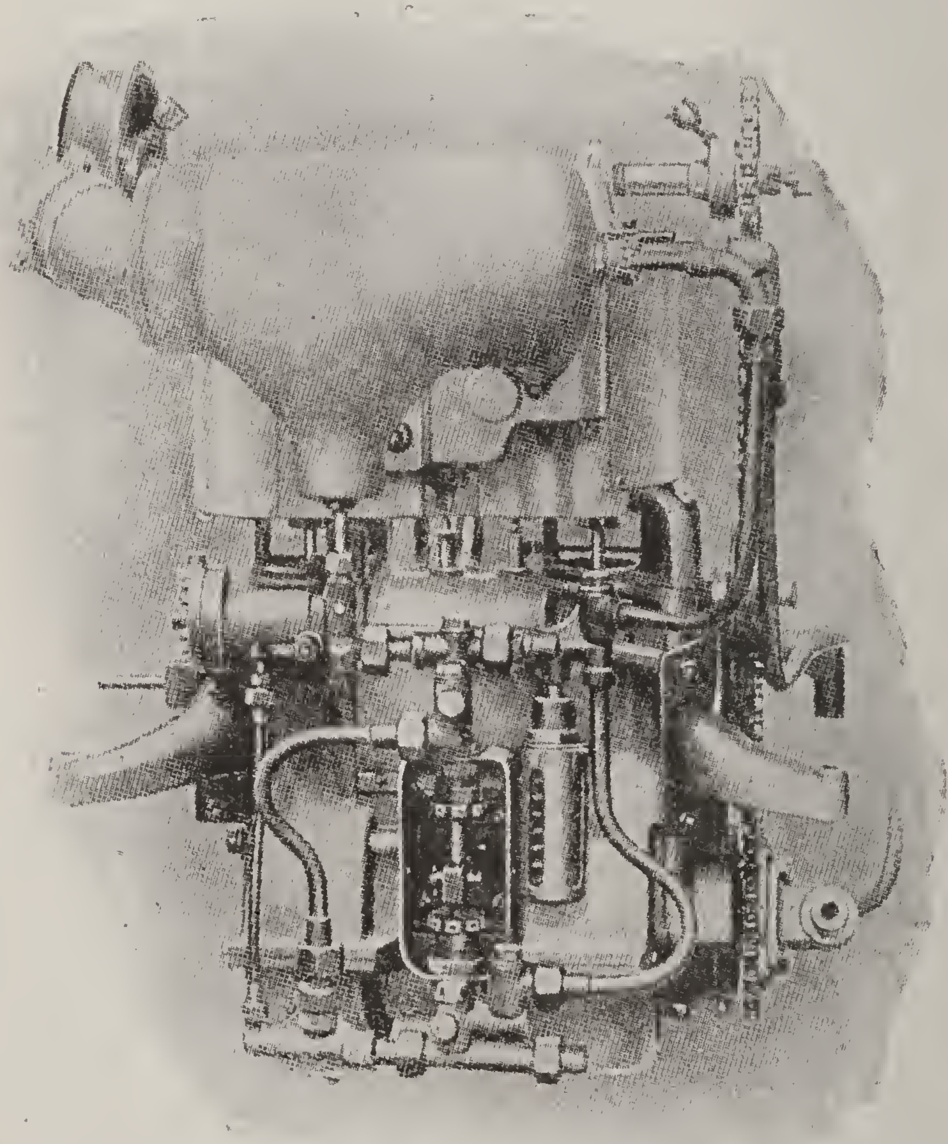


Fig. 289a

WD to the flow motor. The valve V begins opening at a temperature of 450 degrees Centigrade.

The connection P is with a pyrometer which shows the temperature of the steam on the footboard of the car. The accuracy of the py-

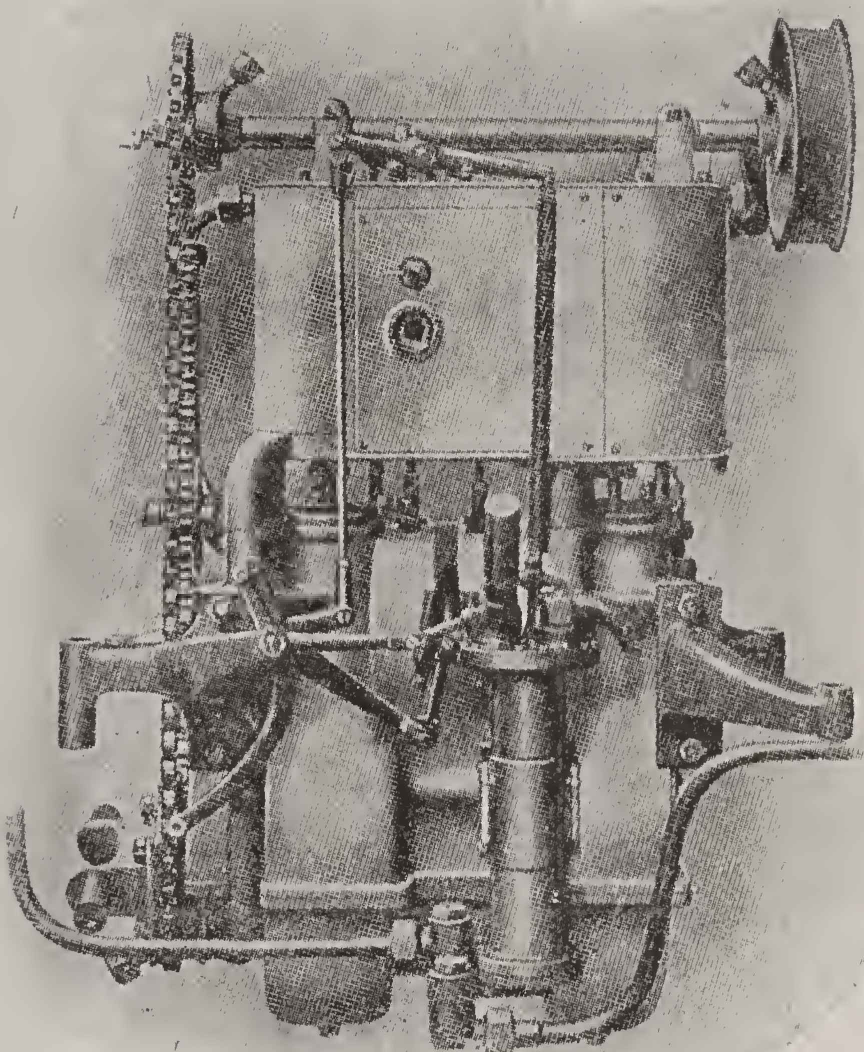


Fig 289b

rometer can be checked up by inserting a thermometer in the steam line at X. Thus do the water, gasoline and steam assist each other in

this steam system. If the steam pressure gets too high it acts through the water regulator, and a portion of the water is thereby sent back to the tank instead of going to the generator

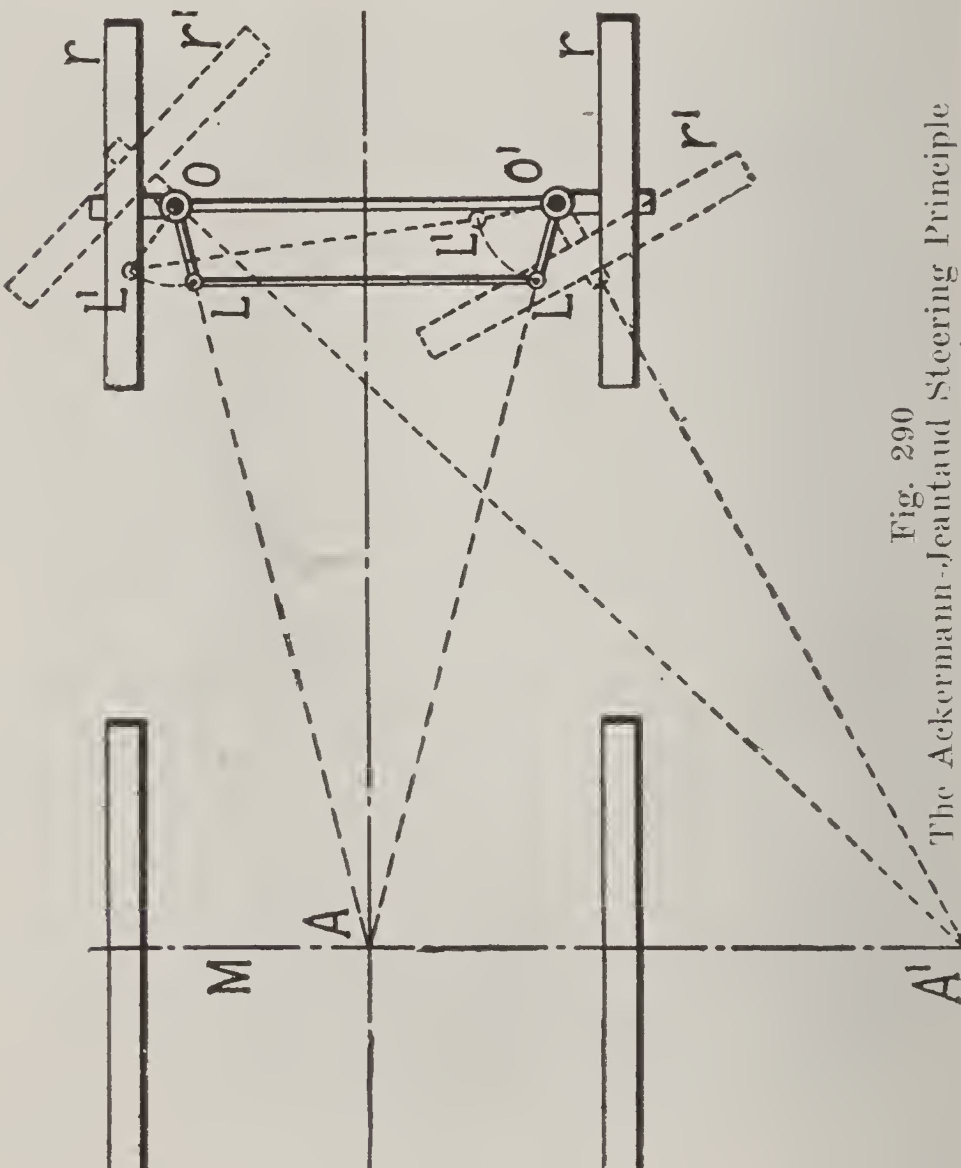


Fig. 290
The Ackermann-Jeantaud Steering Principle

to be made into more steam. The thermostat, when the steam gets too hot, opens a valve and allows more water to reach the generator through the flow motor, thus reducing the steam temperature; and the flow motor lets

gasoline go to the burner in proportion to the water sent to the generator, and if too much water is pumped, returns a portion of it direct to the water tank.

Steering Gear—Principles of. In steering gears the generally accepted principle is that known as the Ackermann-Jeantaud, which was invented in 1878 and is a modification of the

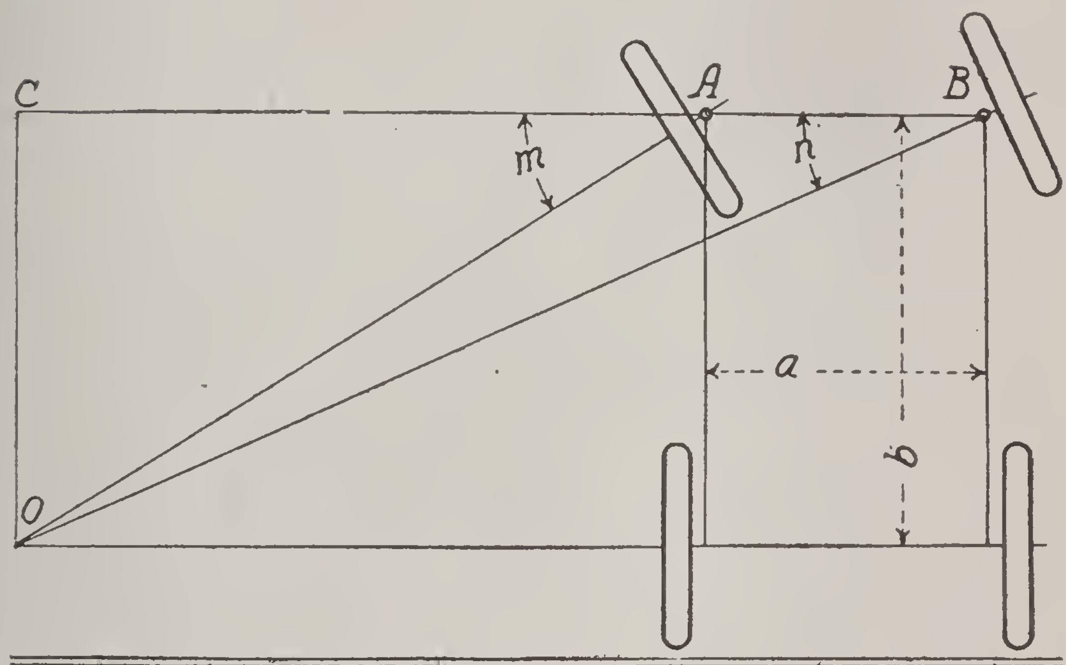


Fig. 291
Designing Steering Knuckle Arms

original Ackermann principle. In the Ackermann-Jeantaud system the steering knuckle arms OL and 01 L1, when produced, meet in the plane of the rear axle or in this plane produced as shown by illustration, Fig. 290. The reader will appreciate that when the tie-rod L L is in rear of the front axle, the steering knuckle arms OL and OIL converge, as illustrated, but should the tie-rod be in front of the axle, these

arms diverge. Strictly speaking, the points A and AI, which are supposed to be in the axle plane, are not so, and the axle line A, AI, is a

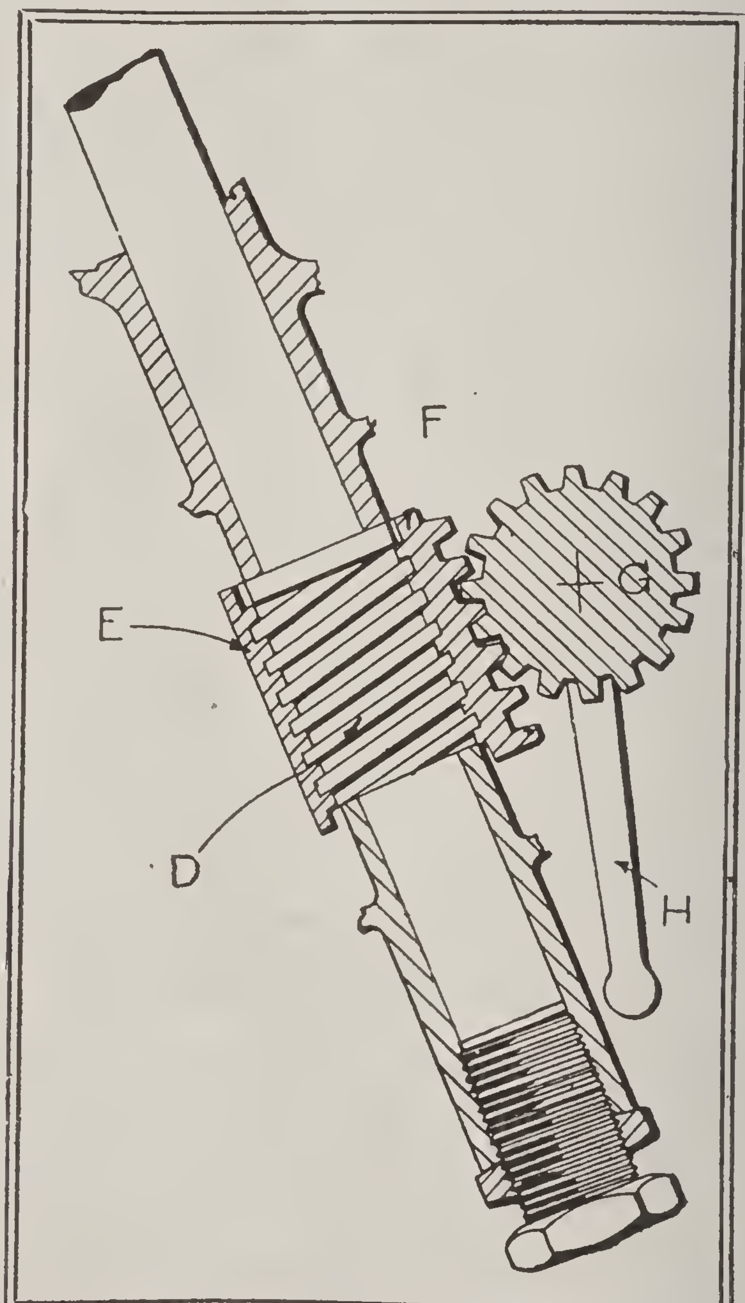


Fig. 292

tangent to the curve in which the points of convergence will fall in a complete sweep of the steering wheels from axle to axle.

Several makers have, however, discontinued the design of steering knuckles on this principle, preferring to design them as illustrated in Fig. 291, in which the produced axis of the front wheels, A and B, intersect the axis of the rear wheel at a given point O. With this condition fulfilled, the vehicle will travel around O as an imaginary center. Enthusiasts of this method of construction agree that the Ackermann-Jeantaud principle is sufficiently accurate for angles of not more than 30 degrees, but for angles varying from 30 to 45 they claim less wear on their tires by the latter construction. The exact arm for the angles in a steering gear of this nature will depend largely on the wheelbase of the car as well as the difference between the steering pivots A and B.

Steering Gear—Types of. Fig. 292 shows a sectional view of the nut and segment type of steering gear, in which there is a worm D on the steering column that engages with the nut E. On the front or gear face of the nut is a rack F which meshes with the sector G, so that as the steering wheel is turned right or left the nut is raised or lowered and the requisite movement imparted to the radius rod H. In certain screw and nut steering gears the sector is not required, the construction being a screw on the steering column on which works the internally threaded nut, and on either side of this nut are trunnions with links which connect with the axis carrying the radius arm.

STEERING GEAR—LOST MOTION IN. If the gear is of the worm and sector type it may be that these two elements are not held in the proper relation to each other. Fig. 293 shows a diagram of this type of gear, and illustrates plainly the point where lost motion will be of the greatest detriment. When the wheel is turned, if there is the slightest end play, the wheel shaft

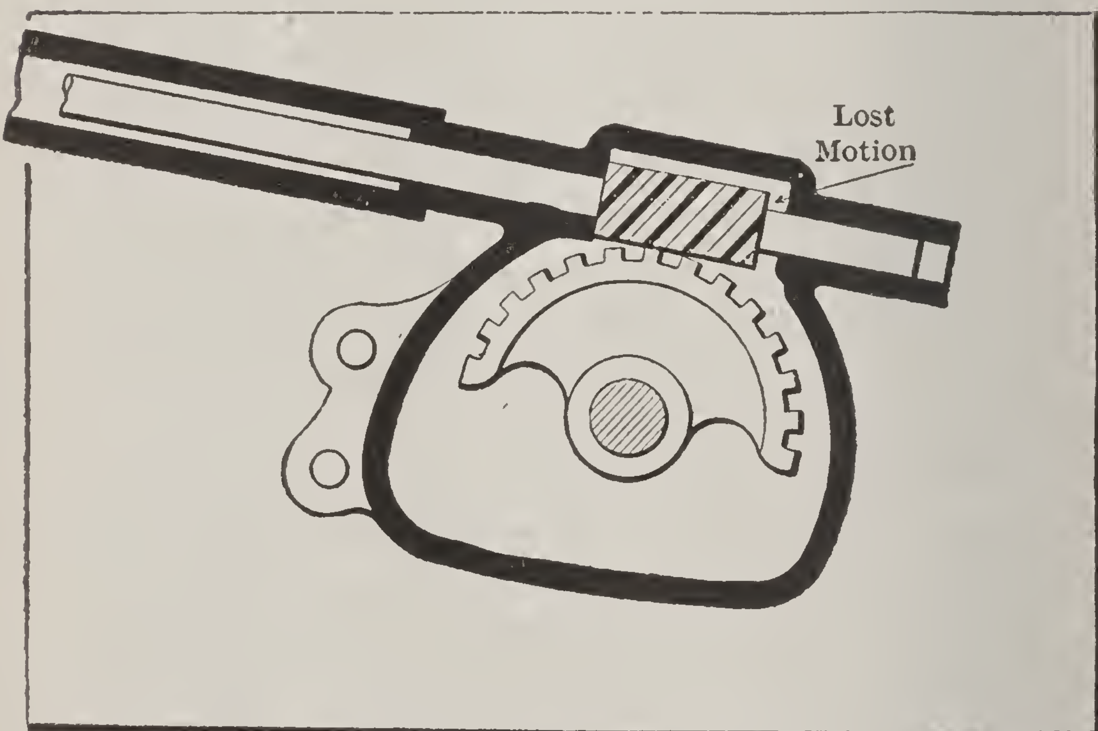


Fig. 293

will respond, but the geared sector will not, until all the end play is taken up, and as strains come on from the road wheels, the sector will rotate to and fro. causing the shaft of the steering wheel to reciprocate and thus allow the road wheels to wobble. To overcome this it is necessary to replace the thrust washer, if there be one, and if necessary, introduce a

washer, made of phosphor bronze, of suitable thickness to take up all the end play of the steering wheel shaft.

Some lost motion will follow if the worm is not set on the pitch line, in its proper relation to the sector; this will be true if the bushings are worn, and when a new thrust washer is made and fitted into place, if the lost motion is still greater than is desired, the only thing remaining is to replace the bearing brasses. When the gear is dissembled it will be possible to dimension the same, and determine by measurement if there is any great amount of journal wear, thus rendering the task less troublesome, since the brasses may be replaced without waiting to determine the remaining lost motion through actual trial.

As a rule, it will be found that the lost motion is due to end play, just as the illustration shows, and not to worn-out journal brasses on which the wear is far less than it is in thrust. If the gear is irreversible, or nearly so, as it is in many automobiles, a little lost motion is to be expected owing to the smallness of the angle of the worm, which can only be irreversible if the angle is such that a little lost motion will be present and unavoidable.

Care of Steering Gear. The steering gear is a very important part of the car, and, as the safety of the occupants may be endangered by any binding, the autoist should give it even more careful attention than the other parts.

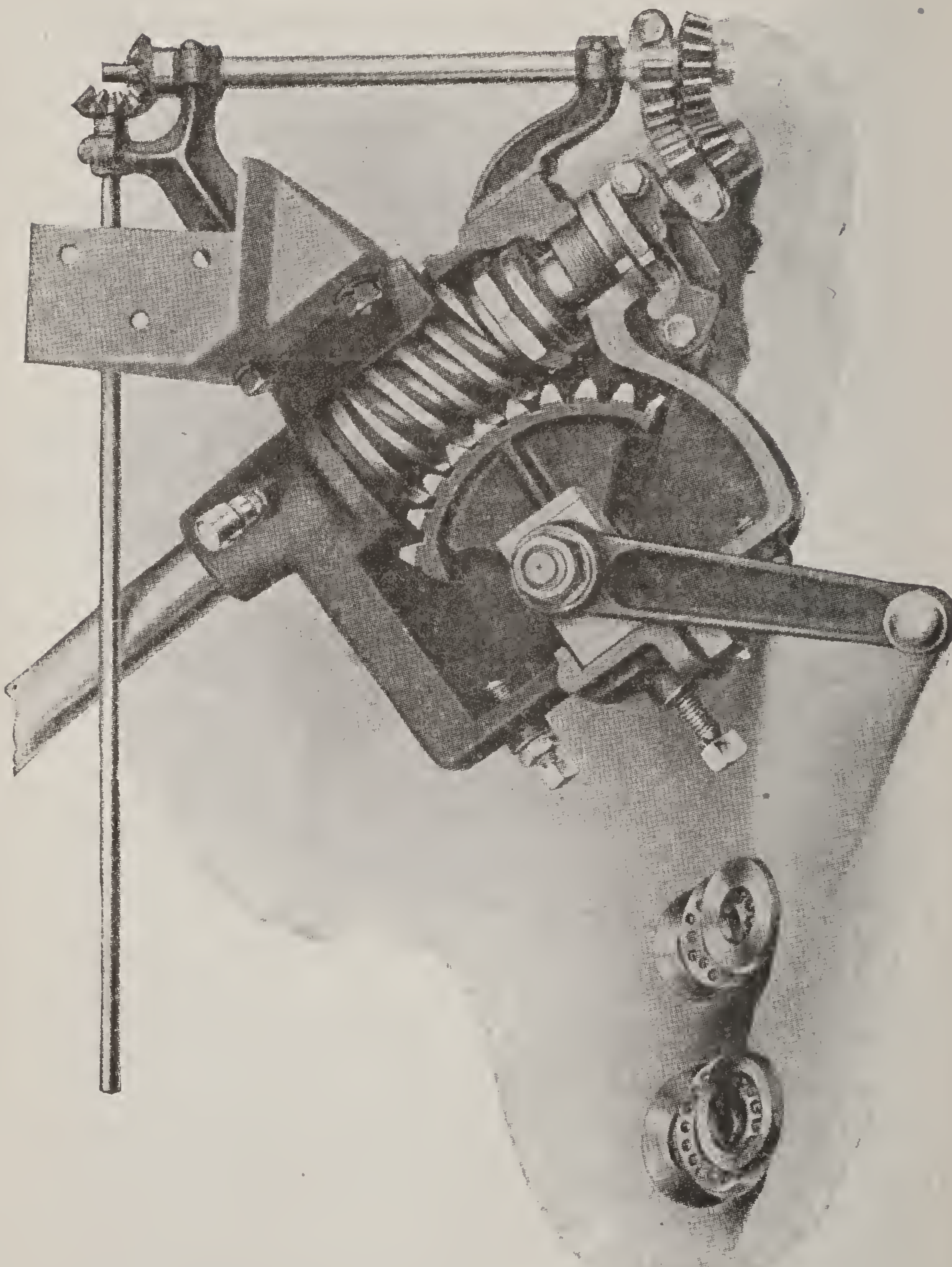


Fig. 293a
Worm and Sector of Steering Mechanism

The gear should be taken down, given a thorough cleaning and examined for possible wear.

In case the steering action is stiff and the wheel turns hard, the ball joint may be out of adjustment due to wear; the steering link may be bent, or the cause may be insufficient lubrication. If there is any considerable amount of backlash, the cause may be looked for in the joints of the levers, in the swivel pin, or in loose bearings.

Stopping a Motor. After the run is finished, and the car is run into the garage, the first work should be to shut off the battery switch and remove the plug.

Close all oil cups or lubricators.

Shut off gasoline if there is no float in the carbureter.

In the winter, and if the car will be in a cold place, drain off the water from the circulating system.

Wipe off the motor, and see that it is ready for the next run.

When cleaning the motor examine all bolts and nuts, and all points needing adjustment.

Note the condition of the journals and bearings, if they are hot, ascertain the cause of heating.

Supplies Necessary on a Car. The following supplies will be found very useful, especially on a long trip: Asbestos, bolts and nuts, copper wire, emery cloth, emery powder, funnel, gasoline (extra can), gaskets, iron wire, machine screws, rope (small, strong), rubber pail, sticky tape, washers.

Suspension—Three Point. Where a three-point suspension is employed, as shown at A, B and C, Fig. 294, no amount of frame distortion will put any stress upon the power plant, or on individual members thereof, and, because of the unit construction, all parts will remain in absolute alignment. The advantages of the unit power plant construction are becoming better appreciated, and when this construction is not

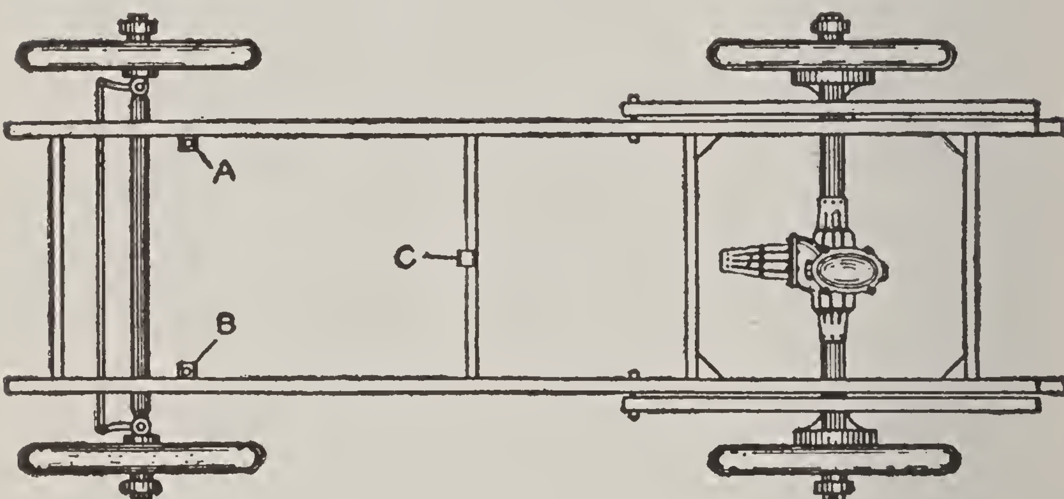


Fig. 294
Three-point Suspension

used the frame members must be proportioned to resist all stresses which might produce distortion, and loss of alignment is prevented by stiffening of the frame.

If an automobile were designed to run upon a perfectly smooth and unyielding surface, such as is presented by the rails of an efficiently maintained railway road bed, there would be no necessity for guarding against lack of alignment.

But as it is compelled to travel roads that represent the furthest possible remove from this ideal, the importance of saving power that would otherwise be wasted in this manner, and of preventing these racking stresses from reaching the parts themselves, will be fully appreciated. When the motor is shoved upward through the action of the car in mounting an obstruction with its forward wheels, and at the same time the rear wheels are either dropping into a depression or mounting another obstruction of a different height, there are heavy stresses tending to twist the frame in several different directions at once. The independent and rigidly mounted members assume all sorts of angles to one another. The motor imposes an additional burden on the clutch by dragging it out of line with the gear-set, and the clutch itself adds greatly to the load the transmission shafts must carry by tending to pull the gear-box into its own distorted plane. Instead of working harmoniously as a properly supported three-part unit, each adds to the burdens of the others, resulting in a constant need for expensive repairs.

It will thus be apparent that it is not alone necessary to combine the essentials of the motor and transmission in the Unit Power-Plant, but that this rigid unit must be so carried that none of the twisting stresses can be transmitted to it by the frame. Assume a rigid rectangle of steel, to which a smaller rectangle of the same mate-

rial is solidly fastened between, and parallel to the long sides of the larger member, and we have the usual frame, and subframe construction. Twist the larger rectangle out of the horizontal plane, as is done by the rough road, and the smaller one will assume a correspondingly distorted angle. Take the large rectangle again, and instead of placing the small one inside it, divide it into three rectangles by riveting transverse members across the forward half. Result, the usual type of frame construction in which each essential is directly mounted on cross pieces forming part of the main frame itself. Twist the latter, as before, and the effect is exactly the same—no two members can remain in the same plane or conserve the same relation to the others.

Instead of employing a second and parallel rectangle, or of dividing the larger into two or three sections, make the second frame triangular, with its base supported on the main frame forward, and its apex flexibly hung on the center of a transverse member at the rear. Regardless of how the main frame, or rectangle, may be twisted, it does not impart the stresses of its distortion to the triangle, which, due to its flexible mounting, is free to maintain its own plane. This in effect is the principle of the Stevens-Duryea three point suspension illustrated in Fig. 294a. The unit power plant constitutes the triangle previously referred to, and it is supported forward by means of two sub-

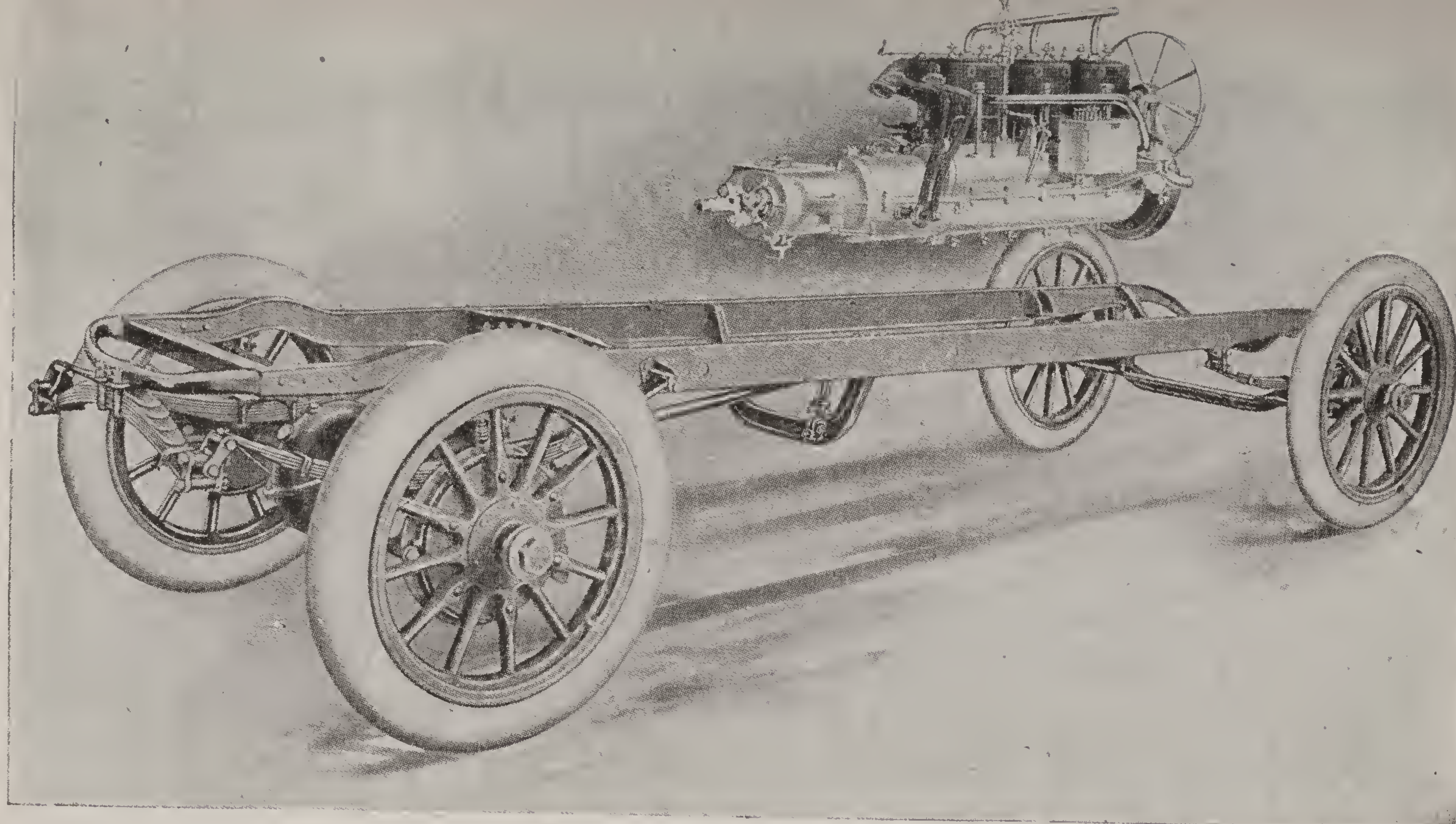


Fig. 294a
Three Point Suspension—Stevens-Duryea Six-cylinder Power Unit Showing Accessibility

stantial aluminum alloy arms cast integral with the crank case, and at the rear on a special support fixed on a transverse member designed to carry it. Fig. 294a also illustrates the accessibility of this system. When it becomes necessary to repair certain parts not easy of access while the power unit is suspended on the chassis, there is no need of laboriously lining its various parts up on the chassis, the entire unit, comprising the motor, clutch and gear-set, may be hoisted out of the car merely by uncoupling the forward universal of the propeller shaft and removing a few bolts. The entire operation consumes only a few minutes.

Tachometer. A tachometer is an instrument for indicating the number of revolutions made by a machine in a unit of time—usually one minute.

Tanks—Capacity of Cylindrical. To ascertain the capacity in gallons of a cylindrical tank of given length, multiply the area of the cross-section of the tank in square inches by the length of the tank in inches, and divide by 231.

Tanks—Gasoline and Water. Do not put the water in the gasoline tank by mistake, as many a new beginner has done. Always use a wire gauze-lined funnel. Although the drain of most tanks is usually a cock, the inlet is more often a screwed cap; this cap gets lost, and is often replaced by a cork. If this is done in the case of the gasoline tank, the results from pow-

dered cork getting into the carbureter and small pipes. is sure sometime to give rise to almost endless trouble.

Always fill or measure the contents of the tanks before starting. When filling the water tank after it has been emptied, do so with the drain-cock open for the first few minutes so as to force out any air bubbles which might get into the pump, or in a bend in the pipes, and

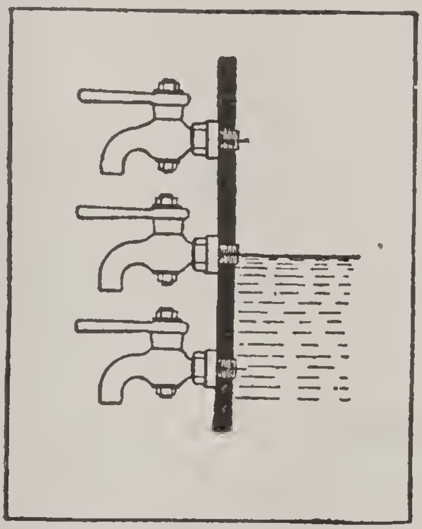


Fig. 295

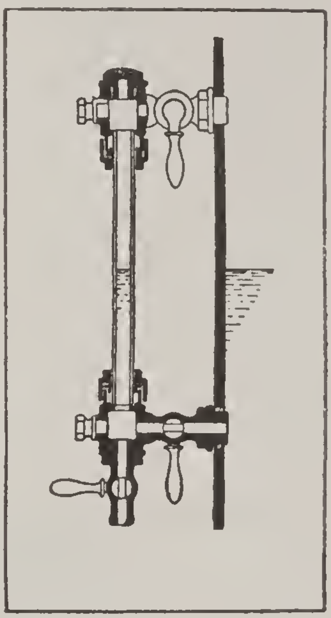


Fig. 296

put a stop to the water circulation. This is known as an air-lock.

In case that there may be difficulty in ascertaining the level of the gasoline in the tank, gauge-cocks may be fitted in the side or end of the gasoline tank. Fig. 295 shows a form of gauge-cock suitable for this purpose.

To determine the exact quantity of water in the tank, a gauge-glass as shown in Fig. 296 is well suited, as the fluid level may be seen at a

glance. In case of accidental breaking of the glass, the cocks at the top and bottom of the gauge may be closed.

Tap-Drills. See Table 17.

TABLE 17.

DIMENSIONS OF TAP-DRILLS FOR STANDARD V-THREADS, FROM ¼ TO 1¼ INCHES.

Diameter of Screw.	Number of threads per inch	Diameter at bottom of thread	Nearest drill for full thread.	Correct size of tap drill.
1-4	20	.163	11-64	3-16
5-16	18	.216	7-32	1-4
3-8	16	.267	17-64	7-32
7-16	14	.314	5-16	23-64
1-2	12	.356	23-64	13-32
9-16	12	.418	27-64	31-64
5-8	11	.468	15-32	35-64
3-4	10	.577	37-64	43-64
7-8	9	.683	11-16	25-32
1	8	.784	25-32	29-32
1 1-8	7	.878	7-8	1 1-32
1 1-4	7	1.003	1	1 5-32

Testing Ignition Batteries. Get a 4 or 6-volt one-ampere incandescent lamp, and after cutting the battery out of the charging circuit, put the lamp in the battery circuit for a few seconds only. If the battery is fully charged the lamp will give out a brilliant light. On no account use an ammeter to test a storage battery. It will injure the battery if kept in the circuit long enough to get an accurate reading.

Tires. A single-tube tire differs from a double-tube tire in the fact that the inner or air-tube is vulcanized to the outer tube. In a double-tube tire they are separately attached to

the rim of the wheel, and are not in contact except when the inner tube is inflated. A puncture through the tread of a single-tube tire may be repaired by the use of rivet-shaped rubber

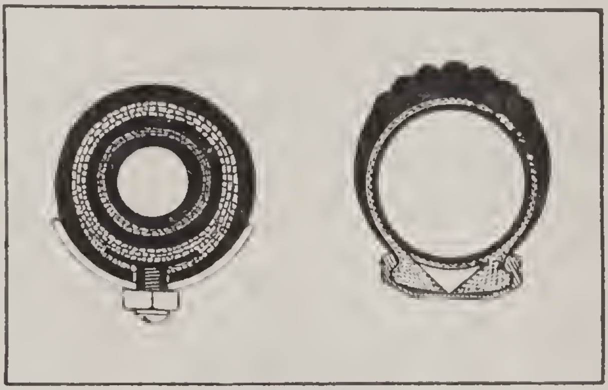


Fig. 297

patches, which are inserted in the puncture and secured in place with cement. With a double-tube tire, the casing must be removed from the rim of the wheel, and suitably sized patches are

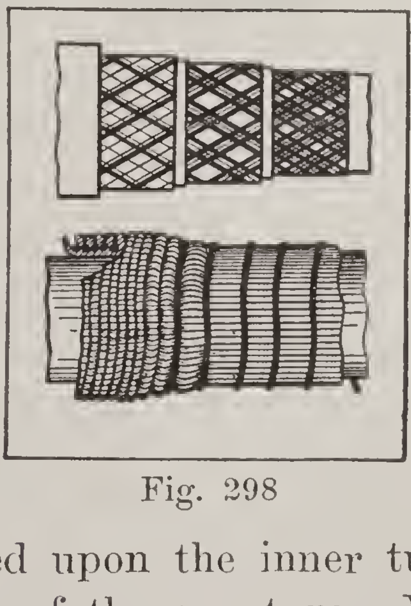


Fig. 298

then cemented upon the inner tube according to the nature of the puncture. When a puncture occurs on the road, the double-tube tire may be repaired in a similar manner to the sin-

gle-tube, and when the tire is inflated, the air is retained by the inner tube, and prevented from leaking through the minute openings in the rubber and fabric of the casing.

Fig. 297 shows cross-sections of single and double-tube automobile tires.

The lower view in Fig. 298 shows a form of single-tube tire composed of a number of strands of thread running lon-

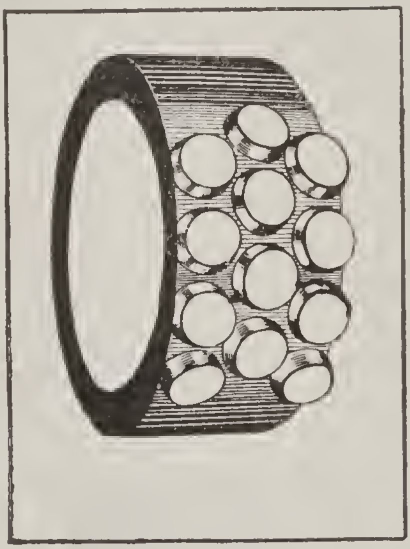


Fig. 299

gitudinally on the tube, and wound spirally with other threads which hold the longitudinal threads securely under inflation. The spiral windings are then pushed along the length of the tube, so as to reduce the distance between the windings from one-quarter of an inch to less than one-eighth of an inch, with the result that the intermediate sections of the longitudinal threads are pushed up into a series of loops, thus forming stronger attachments for the fab-

ric, when held in the rubber wall built up over these layers of threads.

The upper view in Fig. 298 shows a method

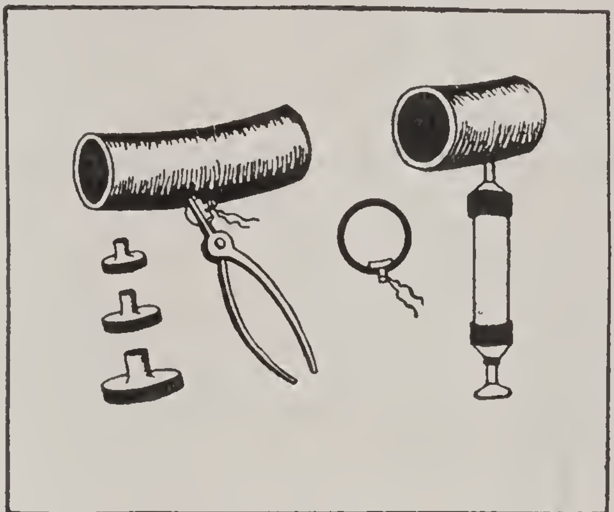


Fig. 300

of strengthening the fabric of a tire against any cause that would tend to burst or tear

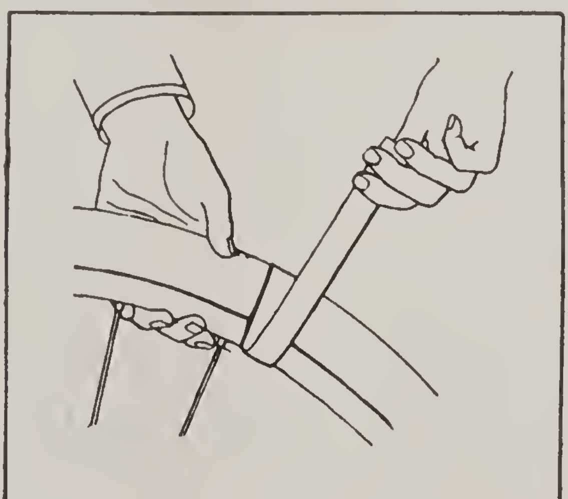


Fig. 301

open the walls, and is a series of plies or layers of thread wound on in diagonally opposite directions, each layer being of a more open con-

struction than the last, the closest winding being on the inner layer of the tire.

A short section of an automobile tire with a tread having circular projections is shown in Fig. 299. It is said to increase the tractive or adhesive properties of the tire, and also to reduce the danger of skidding, or side-slip to a minimum.

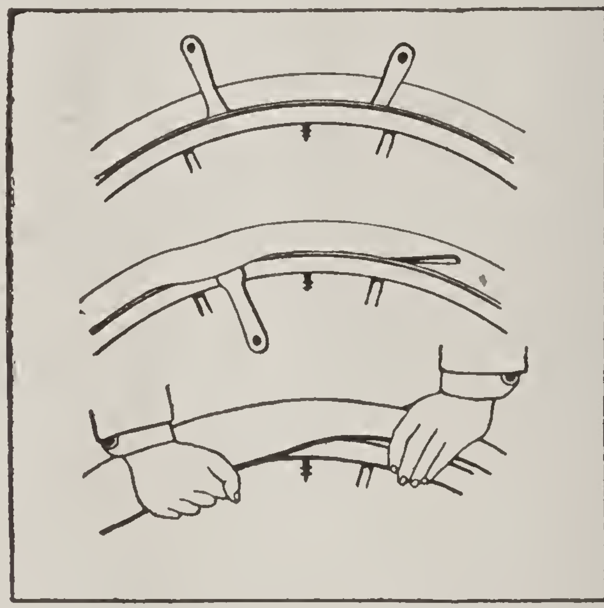


Fig. 302

Tire Repairs. A method of repairing a puncture in a single-tube tire by means of rivet-shaped plugs or patches is shown in Figs. 300 and 301. Fig. 300 shows the manner of making the repair and Fig. 301 the placing of a strap or bandage of sticky tape around the tire and the rim of the wheel. The bandage is usually left on until it wears out.

The manner of removing the casing of a double-tube tire of the clincher type, to make

a repair to the inner tube, is clearly shown in Fig. 302.

Tire Pump. The proper unguent for the cupped leather washer of the tire pump piston is vaseline. Oil is too thin, and it tends to work into the rubber hose, and even into the tire itself if too much is used. Vaseline, on the other hand, clings to the leather and lasts a considerable time. If the leather becomes dry it does not hold air well, and pumping to high-pressure becomes impossible, while the labor of pumping even to low pressure is greatly increased.

Tonneau. The name or term used in connection with the rear seats of a motor car. Literally the word means a round tank or water barrel.

Tools Necessary on a Car. The following tools will not only be found useful but in many cases absolutely necessary on a car: Air pump, cold chisel, densimeter, files, hammer, jack, key puller, knife, monkey wrench, oil can, pliers, scissors, screw-driver, spanners, tire removers, tire-repair-kit.

Touring Car. A car with non-removable rear seats and a carrying capacity of 5 to 6 persons, with from 16 to 24 horsepower, is known as a touring car. Such a car generally has a running radius of 50 to 75 miles on one charge of gasoline and water.

Touring Sundries. Extra parts and supplies

necessary for use when on an extended tour are as follows:

Extra parts: Chain links, batteries, inner tubes, insulated wire, packing, spark plugs, valves, valve springs.

Supplies: Acetylene (carbide of calcium), cylinder oil, goggles, lap robe, lamp oil, lubricating oil, storm apron, tire bandage, waste, whiskey (for emergency use only).

Torsion Rod. When the manner in which the power is transmitted from the change-speed gear to the rear axle on the shaft-driven car is considered, it will be apparent that the turning of the shaft imposes a twisting strain on the whole rear end of the car, and that if it were not for the frame, and the weight of the car on the ground, there would be a tendency to revolve the rear of the chassis around the shaft, rather than to turn the wheels. But it would be bad practice to permit this strain to fall on the frame and hence the office of the torsion rod, which is designed to prevent its reaching that member. On cars that are not provided with independent torsion rods, it will be found that the housing of the propeller shaft has been made correspondingly stronger, and that its supoprt has been designed to enable it to act in this double capacity. This represents a simplification of design that will be found on quite a number of cars, as it eliminates a part exposed to mud and dirt.

Traction of Driving Wheels. A horse which

exerts a pull of about 375 pounds continuously for an hour and goes a distance of one mile in an hour is working at the rate of one horsepower. If for any reason the horse is unable to exert as much as 375 pounds pull when going at the rate of one mile per hour, he is thereby prevented from working at the rate of one horsepower.

The same rule applies to a motor car. When the road is not slippery there may occur a condition which does not appear with horse traction; that the tires fail to adhere to the ground owing to insufficient weight on the driving wheels. In such a case it is impossible for the motor-car to exert a push of 375 pounds without skidding the wheels, and thus it would be impossible for it to work at the rate of one horsepower. With underpowered motor-cars this difficulty does not occur, but to develop 10 horsepower at the rims of the driving wheels while covering the ground at the rate of one mile per hour, the car must exert a push on the road of 3,750 pounds. This is, on touring cars of ordinary weight, impossible, because the weight on the driving wheels is invariably less than 3,750 pounds, while the adhesion with the road is only a fraction of the weight on the rear wheels. As the speed rises, however, the push necessary for the development of 10 horsepower goes down until at 10 miles per hour a push of 375 pounds means 10 horsepower.

Thus a 40 horsepower car, if it could start

work with the activity of forty horses, would, while it was moving at one mile per hour, exert no less a push than 40 x 375, which is equal to 15,700 pounds. This tremendous push is rendered impossible by the fact that the wheels of a car weighing 2,000 pounds only grip the ground enough to exert about 750 pounds push. Beyond this point they will skid.

This shows that a high-powered car, when the car is moving slowly, cannot develop its full power unless the road wheels are capable of adhering to the ground sufficiently to transmit this power. As a rule only about 0.6 of the weight of the car is on the driving wheels, and of that only 0.625 is available for the adhesion (owing to the coefficient of friction between rubber and road being 0.625). So a 10 horsepower car weighing 2,000 pounds cannot exert its full power when the car is starting, nor until it is traveling at 5 miles per hour.

It would be wrong to contend that on all cars having the weight distributed as at present, a 60 horsepower motor is useless, but it is needless to say that the output of such a motor is not availabe at starting or at any speed under 30 miles per hour, although the whole power is more needed then than at any other time. The remedy which suggests itself is by using all the adhesion of the car, that is, to drive with all four wheels.

Transmission of Power—Efficiency of. The efficiency of various forms of drives between

the motor and the driving wheels of a motor car may be estimated as follows:

Single-chain, with direct drive on the high speed, between the motor and rear axle—85 per cent.

Two-chain drive, from motor to speed-change gear, from speed-change gear to rear axle—75 per cent.

Quarter-turn or right-angle drive, with double-chain drive to free rear wheels—70 per cent.

Longitudinal shaft drive, with universal joints and bevel gear in differential case—65 per cent.

Transmission Shaft. The square transmission-shaft used on several highest-powered cars is a nickel steel forging with .25 to .30 per cent of carbon. The treatment is about as follows: First heated in lead bath, then transferred to the cyanide, where it remains 20 minutes, then dipped in cottonseed oil. The shaft then goes to the furnace and is heated to 1,400 degrees Fahrenheit. When removed from the furnace, only the part of the shaft upon which the sliding gears operate is dipped in oil. This class of steel before treatment averages 86,000 tensile strength, after treatment 125,000 to 130,000.

Troubles—Throttle. Slowing down the speed of a motor by throttling the charge, should not be resorted to until the ignition has been retarded as far as possible. If the motor speed be reduced, by first throttling and then after-

wards retarding the ignition, or by a combination of the two, it generally results in misfiring of the motor.

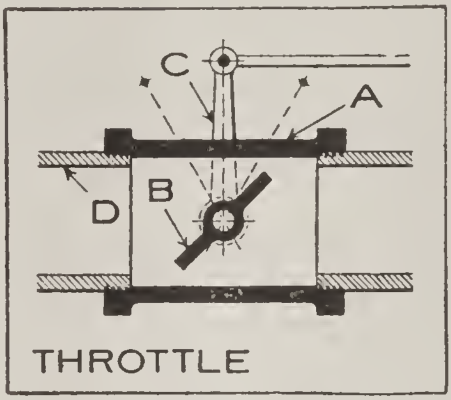


Fig. 303

A butterfly-valve or form of throttle commonly used is shown in Figure 303. The valve-chamber A, has the valve B, operated by the

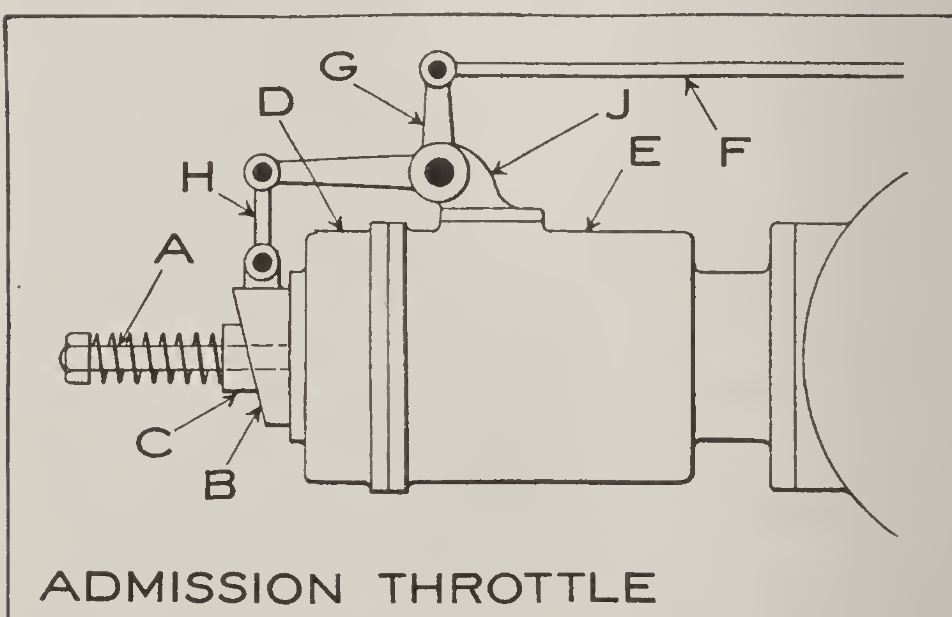


Fig. 304

lever C. The valve is located at any suitable point in the admission-pipe D, between the carbureter and the admission-valve of the motor.

A form of admission-valve governor or throttle is shown in Figure 304. The pressure of the spring on the admission-valve stem A is increased or decreased by means of the wedge B, acting on the taper washer or collar C. The valve is located in the cylinder-head or combustion chamber D, of the cylinder E, and is operated by means of the rod F, through the bell-crank lever G, and link H. The bell-crank lever is carried by a bracket J, on the top of the cylinder, as shown.

Tubing. Copper tubing is considerably used for piping the gas to the burners, but it is liable to erosion by the gas, and standard ⅛-inch gas pipe is better and lasts longer. The gas bag and rubber lamp connections should be kept clean and not painted, as is often done to correspond with the car, as paint rots the rubber, with the result that it is soon unserviceable, and must be replaced. When the rubber is to be washed, only water should be used and the goods should be carefully dried before putting them in service again.

U and H Magneto. The particular feature of this magneto is that the starting spark is a maximum, whether the crank is turned slowly or fast.

In the operation of the U and H magneto. Fig. 305, a low-tension current of electricity is generated by the rotation of the armature of the magneto. An interrupter, or timer, interrupts the flow of this low-tension current at the

proper time, this interruption causing a high-tension current, similar to that delivered by the induction coil of a battery ignition system, to be induced in the rotating armature by a peculiar arrangement of the windings of the armature. The high-tension current is conducted to a so-called distributer, the duty of which is to

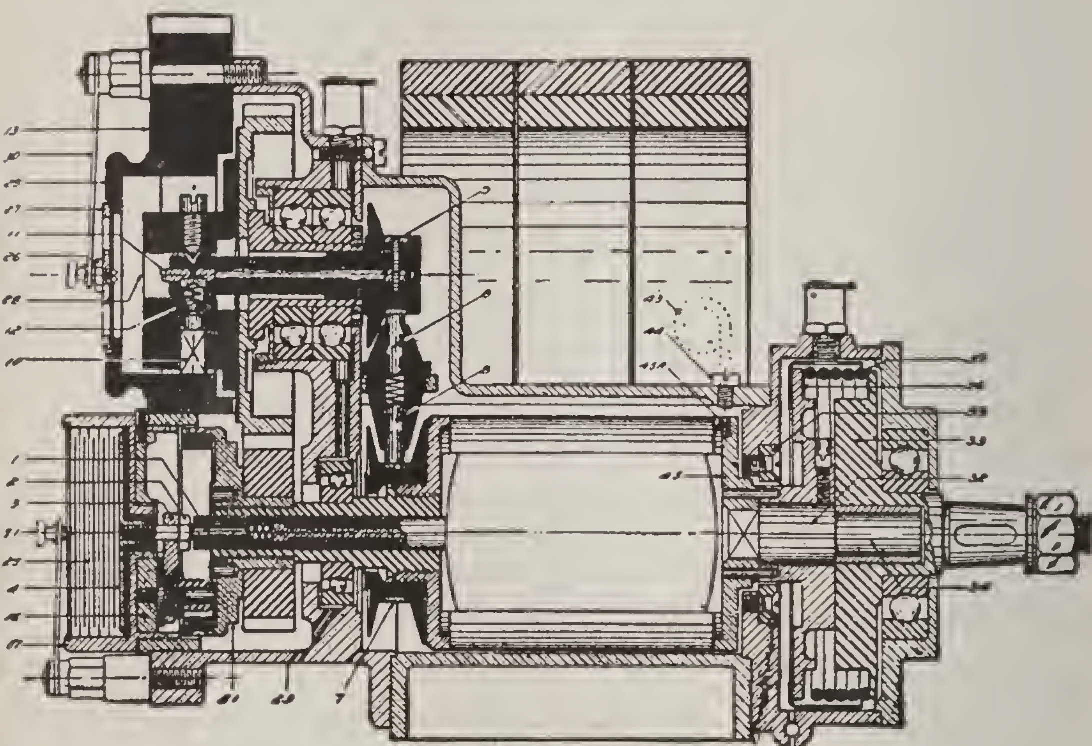


Fig. 305
U. & H. Magneto

distribute the high-tension current to the spark plugs of the various cylinders in the proper sequence of firing. The wiring diagram of the U and H magneto is shown in Fig. 306.

The magneto consists of three pairs of permanent horseshoe magnets, placed parallel, and having secured to each of their free ends a soft iron block. These blocks are exactly

alike, and form a permanent magnetic field. They are bored so as to allow an armature to revolve between them. The armature is of the shuttle type, and is provided with a double

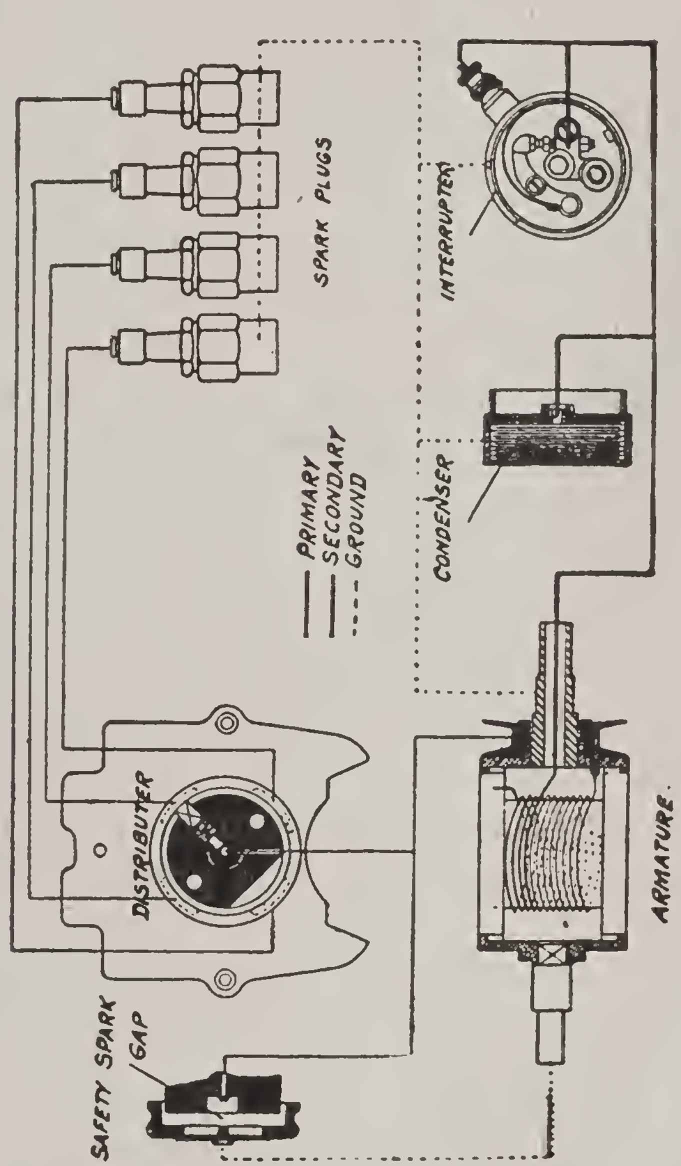


Fig. 306
Wiring Diagram of U. & H. Magneto

winding. The inner or primary winding consists of a few layers of coarse insulated wire. The outer or secondary winding consists of a great number of layers of fine insulated wire. The beginning of the primary winding is

grounded to the armature itself. The end of the primary winding is connected with the carbon brush 1, which is carefully insulated from the armature shaft. Brush 1 bears against the interrupter block screw 2, which in turn conducts the current to the interrupter block 3, and to the condenser plate 4. From the interrupter block 3 the current is conducted by means of the platinum pointed interrupter contact screw 5 to the platinum contact on the interrupter lever 6. The interrupter lever 6 has metallic contact with the body of the magneto, and is therefore grounded and in electrical connection with the beginning of the primary winding. It will be seen that when the interrupter lever 6 is in contact with interrupter contact screw 5, the primary circuit is closed, and the primary winding of the armature is short-circuited.

The beginning of the secondary winding is connected to the end of the primary winding, being in fact a continuation of the primary winding. This fact should be borne in mind, as it has direct bearing upon the results attained with this magneto. The end of the secondary winding is connected to the armature slip ring 7, which is thoroughly insulated from the armature. From the armature slip ring 7 the current is conducted by means of the brushes 8-8 to the distributer slip ring 9, from whence it is led to the distributer brush 10 by means of the distributer brush spring seat 12.

The distributer plate 13 is provided with as many brass distributer segments 14, evenly spaced around the distributer bore, as there are cylinders to be fired, and as the distributer brush is revolved it comes into contact in succession with the segments. These segments are in turn connected with the secondary terminals 15, located at the top of the distributer plate, one terminal for each cylinder. From these terminals the high tension current is conducted

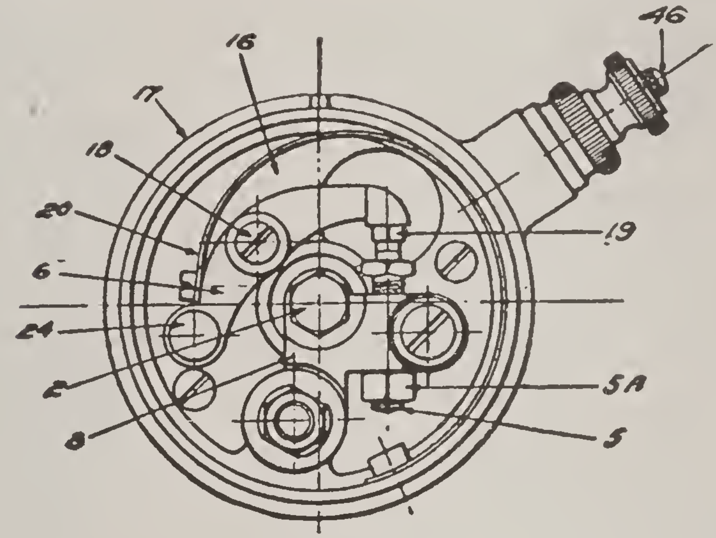


Fig. 307
U. & H. Magneto Interrupter

by cables to the spark plugs of the cylinders, from whence, after jumping the gap it is conducted to the grounded end of the primary coil, through the primary coil to the beginning of the secondary winding, thus completing the secondary or high tension circuit.

U AND H INTERRUPTER. The interruption of the primary circuit is accomplished by the interrupter, as shown in Fig. 307. This device consists of the interrupter plate 16, which is

located in the interrupter 17. Attached to the interrupter plate 16 is a stud 18, upon which is pivoted the interrupter lever 6. The interrupter lever is provided with a platinum pointed contact screw 19, which is normally held by the flat spring 20 in contact with the platinum pointed interrupter contact screw 5. The interrupter contact screw 5 is connected to the end of the primary winding, as already described.

Keyed to the interrupter end of the armature shaft, and rotating positively with the armature, is the interrupter cam housing 21. Securely attached to the interrupter cam housing is the interrupter cam 22, consisting of a ring of hard fiber, having on its inner face two projections or cam faces 22A.

The interrupter housing 17 is held in accurate alignment with the interrupter cam 22 by the construction of the rear end plate 23, and as the armature revolves the projections 22A-22A are brought into contact with the interrupter cam pin 24, causing a movement of the interrupter lever 6 sufficient to separate the contact screws 5-19, and thereby interrupt the primary circuit twice in every revolution. As the projections 22A continue to revolve, the interrupter lever 6 instantly resumes its normal position, and completes the primary circuit. The entire housing of the interrupter is easily removed for inspection, or adjustment by pushing the spring clip 31 to either side.

U and H Starting Device. The easy starting device used in connection with the U and H magneto is shown in Fig. 308. It consists of an arrangement whereby the armature is given a partial revolution at a very high rate of speed, this partial revolution carrying poles of the armature across from one pole of the magnetic field to the other, the highest speed occurring at the point where the maximum cur-

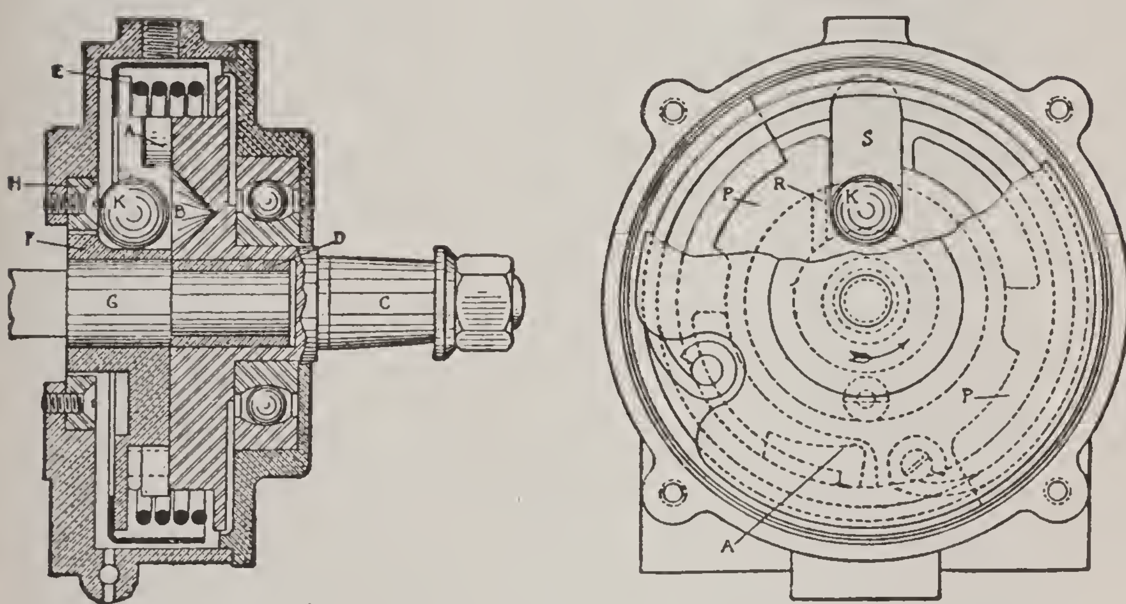


Fig. 308
Details of U. & H Starting Device

rent is generated. The partial revolution at high speed may be produced at each revolution of the armature by slowly rotating the starting crank, thus making it possible to start a motor directly on the magneto, with no more inconvenience than is experienced in starting on batteries, the starting crank not requiring a continuous rotation, but simply an upward pull of half a revolution in the case of a four cylinder

motor. The speed at which the crank is rotated may be infinitely slow, yet at the proper time an intensely hot spark will be produced.

These results are attained by having the armature shaft G at the driving end journaled in the armature driver C, the shaft being perfectly free to rotate in its bearing D. Rigidly attached to the shaft G, and armature head is the driving flange F. The armature driver C is provided with two lugs, A, of peculiar form, 180 degrees apart, which engage with corresponding surfaces P, formed on the driving flange F. These lugs serve both to prevent rotation in one direction, and to preserve the proper relative positions between the armature driver C and the driving flange F, under normal running conditions. A heavy helical driving spring, E, of a large diameter, is placed between the armature driver C and the driving flange F, and has one end securely attached to each. In assembling, this spring is put under sufficient tension to cause the lugs A to engage with their corresponding faces P, on driving flange F, and considerable effort is required to separate the lugs from the faces by reason of the spring tension. Milled into the driving flange is a ball slot, S, in which a steel ball K, of approximately half an inch diameter, is loosely fitted, being free to move radially from a position close to the armature shaft, outward, until further movement is prevented by the driving spring E. Rigidly attached to the

starting device casing is a cam ring, H, having upon its face a hardened cam-like projection, R. The form of this projection R is such that it will engage the steel ball K as it revolves with the driving flange F in one direction, but if turned in the other direction it simply pushes the ball out of its path. In the armature driver C is a depression B, into which the ball may slip at the proper time, and thereby clear the end of the cam R.

Unit of Heat. The heat unit or British thermal unit (B. T. U.) is the quantity of heat required to raise the temperature of one pound of water one degree, or from 39° to 40° F., and the amount of mechanical work required to produce a unit of heat is 778 foot pounds. Therefore the mechanical equivalent of heat is the energy required to raise 778 pounds one foot high, or 77.8 pounds 10 feet high, or 1 pound 778 feet high. Or again, suppose a one-pound weight falls through a space of 778 feet or a weight of 778 pounds falls one foot, enough mechanical energy would thus be developed to raise a pound of water one degree in temperature, provided all the energy so developed could be utilized in churning or stirring the water.

Valves. A valve in a very bad or pitted condition causes bad compression, and the exhaust-valve should be ground occasionally. After grinding the exhaust-valve be sure that there is ample clearance between the valve and the

lifter. It should have not less than one thirty-second of an inch, otherwise when the valve becomes hot it will not seat properly, poor compression being the result. In grinding a valve there is no occasion to use force, and the grinding should be done lightly, the valve being lifted from time to time so that any foreign substance in the emery will not cut a ridge in the seat, or the valve itself. After grinding the valve always wash out the valve seat with a little kerosene, and be careful that none of the emery is allowed to get into the motor cylinder.

Valves which need reseating should first be ground in place with fine emery and oil, then finished with tripoli and water.

A good mixture for grinding valves may be made by using fine emery and cylinder oil mixed in the form of a paste convenient to work with.

Exhaust-Valve Sticking. Sometimes a motor may suddenly stop from the failure of the exhaust-valve to seat properly. This may be due to the warping of the valve, through the motor having run dry and become hot, or it may be from the failure of the valve spring, or the sticking of the valve-stem in its guides. The valve should be removed, and the stem cleaned and scraped, or straightened if it requires it, until it moves freely in the guide, and the spring is given its full tension. If the valve still leaks so that the motor will not start or

develop sufficient power, the valve will have to be ground into its seat.

Auxiliary Air-Valve. It has been determined from the result of experiments that to get the maximum power at any speed from a gasoline motor equipped with a float-feed carbureter, the jet of the carbureter must have a larger opening for low speeds than for high speeds. As this practice would require a very delicate adjustment it consequently becomes almost impracticable, because necessitating a constantly varying regulation for each fractional variation of speed of the motor. The difficulty may be obviated by the use of an auxiliary air-valve, located in the induction-pipe close to the inlet-valve of the motor.

The jet of the carbureter is set for the maximum quantity of gasoline at the slowest speed of the motor, and as the speed is increased the auxiliary air-valve comes into action and reduces the supply of air passing through the carbureter, thereby reducing the suction or partial vacuum at this point, and maintaining a constant quality of mixture at all times.

Valve-Stems—Weak Points of. Recent experiences call attention to the fact that a change is necessary in the construction of valves, or rather that part of the valve attachments adopted, by some designers, to hold the spring in position. This remark applies particularly to the vertical type of valve, but the same defect has been found in horizontal valves.

Opinions vary as to the best method of securing the springs in position, some designers preferring pins, either round or square, others the nut and cotter. Both have points in their favor and some common faults. It is doubtful, however, whether the method of slotting, or broaching the stem, and then using a key for securing the spring, is as secure as that of using a nut and pinning it to prevent its becoming loose. Under the latter plan there is no drilling of the stem except for a small cotter or split pin and the nut carries the strains, whereas in the other method the strain bears on the stem at the point at which the slot is made for the key, the latter being the means by which the strain is carried to the stem. Especially is the slotting of the stem unsafe when the stem is hardened, for vibration plays havoc with the valve. Many breakages have occurred from this cause and the question has become serious. While it is a fact that both kinds have suffered, the nut method of fastening is to be preferred, from the fact that even though the split pin may break and drop out, and the nut become loose, the trouble can be temporarily remedied by an extra piece of wire, while the slotted stem breaks off at a point where the metal is thinnest and makes the valve useless.

Timing the Valves. The movement of the valves should always be timed to give the proper results. This is an important point to remember. The exhaust-valve cam shaft on a

four-cycle motor is usually driven by the two to one gear on the crank shaft, and if for any reason the gears are taken apart and put together, even if only one tooth is out of place, it will throw the valve and spark mechanism out of time.

To ascertain if the exhaust-valve of a motor is properly timed, turn the flywheel over slowly, and notice at what points the exhaust-valve opens and closes, and when the ignition takes place.

The exhaust-valve should open slightly before the beginning of the inward stroke and close at the end of the same stroke. The next inward stroke is the compression stroke, when both valves should be closed.

BUTTERFLY-VALVES. This form of valve is generally used in the admission-pipe between the carbureter, and the admission-valve of the motor, to regulate or throttle the supply of explosive mixture to the motor.

SWING CHECK-VALVE. Valves with a hinged disc, usually set at an angle of 45 degrees, are sometimes attached to the air-inlet opening of the carbureter to prevent leakage of the mixture, when atmospheric or suction operated admission-valves are used.

GLOBE VALVES. This form of valve is usually placed in the outlet pipe of the gasoline tank, to shut off the gasoline from the carbureter.

Valve Clearance. A large number of motors, especially old ones, are unnecessarily noisy be-

cause of superfluous clearance between the valve lifters and the valves, and a great part of the noise may be eliminated simply by the expenditure of a little time and care in reducing this clearance to the minimum. Every valve cam, no matter what its shape otherwise may be, is tangential at the first and last portions of the valve's movement. The sooner the valve takes hold of the cam on the lift, and the later it lets go on the descent, the slower will be the

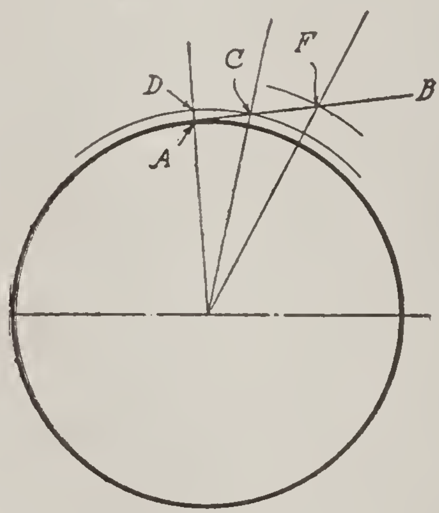


Fig. 309

movement of the valve at these instants, and the less will be the shock both of the lifter on striking the valve stem, and of the valve head on meeting its seat. Fig. 309 shows this clearly. The tangent line A B starts at A, and during the arc D C the rise of the cam amounts only to a minute distance A D. During the following equal angle, however, the lift is three times as great.

The objection to an excessive clearance is not

simply the vertical hammering, but the sidewise pressure imposed on the valve-lifters by the cams, particularly at the instant of opening the exhaust-valves. If it were possible to operate the valves with no clearance whatever, and if there were no lost motion, and if the whole mechanism were ideally rigid, the line of pressure of the cam at the instant could be said to

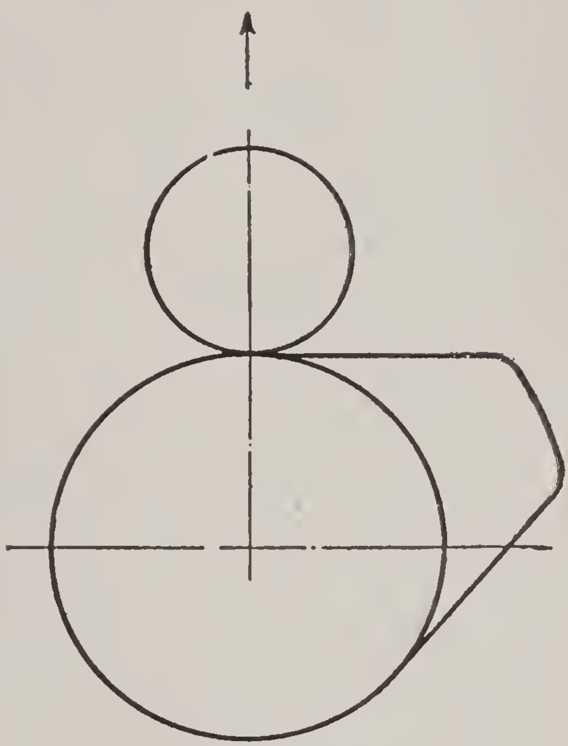


Fig. 310

be vertical, and there would be no side thrust till the valve was off its seat and the pressure of the gases on the valve was partly equalized. As the matter actually stands, however, there is a side thrust which is considerably increased by unnecessary clearance, as comparison of Figs. 310 and 311 clearly shows. In Fig. 310 there is no clearance, and the tangent to

the line of contact is horizontal. In Fig. 311 there is a clearance, AB. The thrust acts at right angles to the tangent along the line C D, and if C E represents by its length the force required to overcome the pressure on the valve and the force of the spring, there is a horizontal thrust equal to D E. It goes without saying

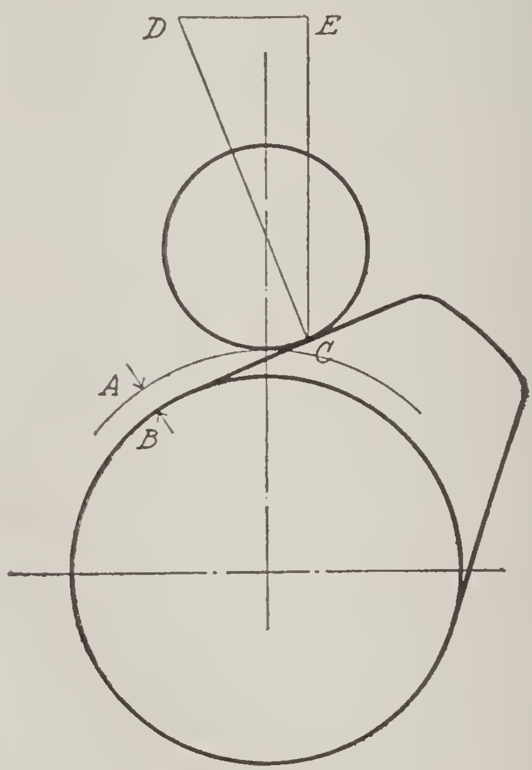


Fig. 311

that valve-lifters thus adjusted will wear loose in the guides faster than they should. As the gas pressure on the valve head may amount to 30 or 40 pounds per square inch the instant before the valve is open, there is an evident tendency to wear a hollow in the cam at the precise point where it starts the exhaust valve from its seat. Evidently, moreover, the smaller the

clearance, the greater will be the leverage of the cam, and the smaller will be its wearing tendency.

The precise amount of minimum clearance is hard to state arbitrarily. The thickness of a business card or about 10-1,000th of an inch is ample allowance for the expansion of valve stems for the average length.

Valves—Lead of. The higher the speed of the motor the greater the necessity for giving both the exhaust, and the inlet valves what has come to be known as a "lead," in that they open before the completion of the particular part of the cycle that they are intended to perform. It must be borne in mind that time is required to set a thing in motion and to stop it, regardless of its form or weight, and this is true of a gas, which has inertia the same as other substances. Further, an appreciable period, though very short indeed, is required for the creation of the vacuum in the cylinder. The gas does not rush into the combustion chamber the moment the inlet valve opens; the piston must have traveled downward a bit before this takes place and the column of gas then rushing in attains an increasing velocity as the piston approaches the lower center. In fact, it is at its greatest speed when the piston reaches the lower dead center so that the first part of its return travel has little or no effect on the incoming gas, which accordingly continues to pour into the cylinder, until the piston reaches a point on its upward

stroke, where its compression is sufficient to overcome the inertia of the stream of gas, and this is the point at which most designers of high-speed engines set the inlet valve to close, thus permitting of the suction of the greatest possible quantity of fresh gas.

Vibrator Coil—Current Used With. A properly designed vibrator coil will not use as much current as a plain jump-spark coil. The self-induction in the primary circuit caused by the high frequency of the pulsations tends to check the flow of the current to a far greater extent in a vibrator coil than in a plain jump-spark coil.

Vaporizers. Vaporizers are much less common now than they were several years ago. They are very wasteful of gasoline, and require frequent adjustment to make them supply the proper mixture. One of their most obvious disadvantages is, that the gasoline will flow more rapidly to the needle valve when the tank is full than when it is nearly empty, on account of the difference in pressure due to the height of the surface above the valve. The proportion of air to gasoline is also not entirely constant when the engine speed changes, or when the engine is throttled. There is a tendency for the mixture to be too rich at high engine speeds, since the flow of gasoline is not only due to the pressure from the elevation of the tank, but is also due to the partial vacuum existing in the mixing chamber, and to the velocity of the air.

Even if no vacuum existed in the mixing chamber and if the gasoline had no pressure at the needle valve, the gasoline would still be drawn into the air by the velocity of the latter. It will thus be seen that there are four factors that affect the proportions of the mixture; namely, the head of the gasoline in the tank, the lift of the needle valve, the vacuum in the mixing chamber, and the velocity of the air. What is really desired is that only the last named of these four factors should be operative; or, in other words, that the velocity of the gasoline jet should be in direct proportion to the velocity of the air. This is not attained in the type of carbureter just described.

Vapor Tension. The saturation point for any given vapor depends on the temperature. If the temperature is increased, more vapor will be given off, and a reduction of the temperature will cause a portion of the vapor to condense. An increase in the quantity of vapor in a given space implies an increase in its pressure, and consequently it follows that the pressure at which saturation occurs depends on the temperature.

Every vapor exerts a certain amount of pressure, although the pressure may be much less than that of the atmosphere. Even the mercury vapor in the almost perfect vacuum of the barometer has a slight amount of pressure. The vapors of volatile liquids, or liquids that vaporize readily, are given out much more abund-

antly, and their pressure under the same conditions is therefore much greater. For the same temperature, each liquid has its own vapor pressure. At 68° F., the pressure of saturated ether vapor is twenty-five times the pressure of saturated water vapor. The pressure exerted by any vapor in its saturated state is often spoken of as the vapor tension for that temperature.

Water Circulation. There are two systems of water circulation in use for cooling the cylinders of explosive motors: The natural or thermo-siphon system and the forced water circulation.

In natural or thermo-siphon water circulation the fact that cold water is heavier than hot water is taken advantage of. A head of water is obtained by placing the tank above the level of the cylinder water-jacket, and as the water in the jacket is heated by the combustion, the cooler water from the tank flows in, forcing the heated water in the tank to take its place, and in this manner an automatic circulation of water is set up. The pipes must be so arranged that they offer every facility for the free circulation of the water, the cold water leaving through a pipe at the bottom of the tank and entering at the lowest point of the cylinder, while the hot water leaves the top of the cylinder and enters the tank at the side near the top. The water circulation, though automatic, is very slow, and for this reason requires a

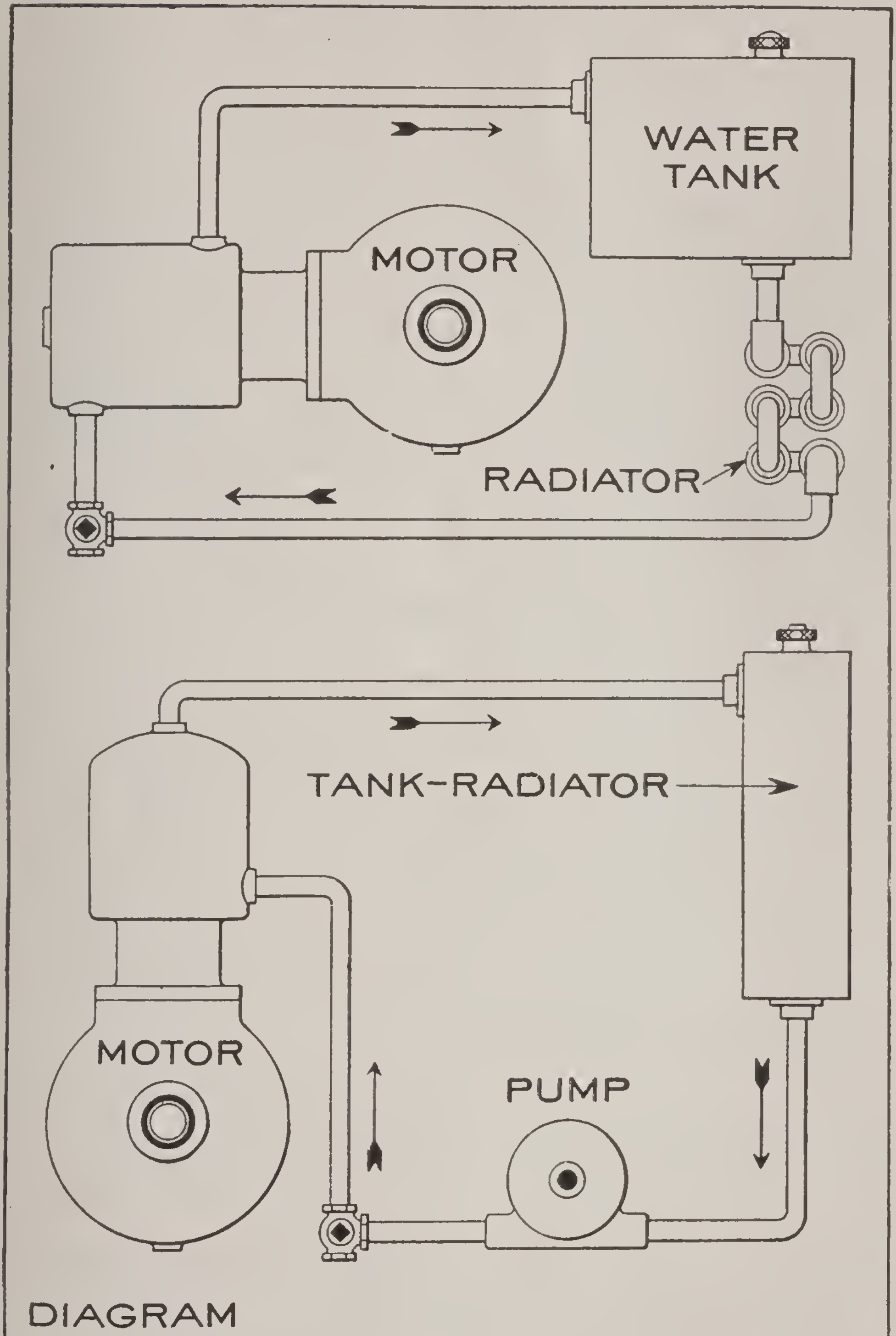


Fig. 312

larger body of water to produce as good a cooling effect as a forced circulation.

In forced circulation a rotary pump is used,

the direction of the flow being such that the water passes from the pump to the cylinder, thence to the radiator, on to the tank, and then through the pump again, thus completing its circuit. The water in this way gets the maximum cooling effect from the radiator, and the body of water in the tank is kept cool. On account of the high speed of a gasoline automobile motor. and the comparatively small amount of power required to circulate the water, rotary pumps are much used. As there are no valves to get out of order, and high speed is obtainable. this type of pump is very suitable for automobile use.

The upper and lower views in Fig. 312 show the principles of operation of the gravity or thermo-siphon, and the forced or pump circulating systems respectively. The volume of cooling water required for the tubular type of radiator is about 13 cubic inches per horse power.

Watt-Hour—Definition of. A current of one ampere flowing in an electric circuit, with an electro-motive force of one volt, is equal to one volt-ampere or one watt. The voltage of a circuit, multiplied by the rate of the current flowing in amperes, gives the rate of work, or energy expended in watt-hours.

TABLE 18.

Elements	Atomic Weights
Hydrogen, H	1
Oxygen, O	16
Nitrogen, N	14
Carbon, C	12
Sulphur, S	32

Weight—Atomic. The atomic weight bears a direct relation to specific gravity.

The atomic weights of the elements most often found in fuels are given in Table 18.

With the aid of these atomic weights, the composition of any substance by weight can be found when its formula is known. Take, for example, water, H_2O, which has two atoms of hydrogen to one of oxygen, and multiply the number of atoms of each by the atomic weight of the element; the results will be the parts by weight of the elements. Thus,

2 atoms of H $\times$ atomic weight, 1 = 2 parts of H

1 atom of O $\times$ atomic weight, 16 = 16 parts of O

18 parts of H_2O

Then, the water is composed of 2 /18 = 11.11 per cent of hydrogen, and 16/18 = 88.89 per cent of oxygen.

As another example, take carbon dioxide, CO_2, in which,

1 atom of C $\times$ atomic weight 12 = 12 parts of C

2 atoms of O $\times$ atomic weight, 16 = 32 parts of O

44 parts of CO_2

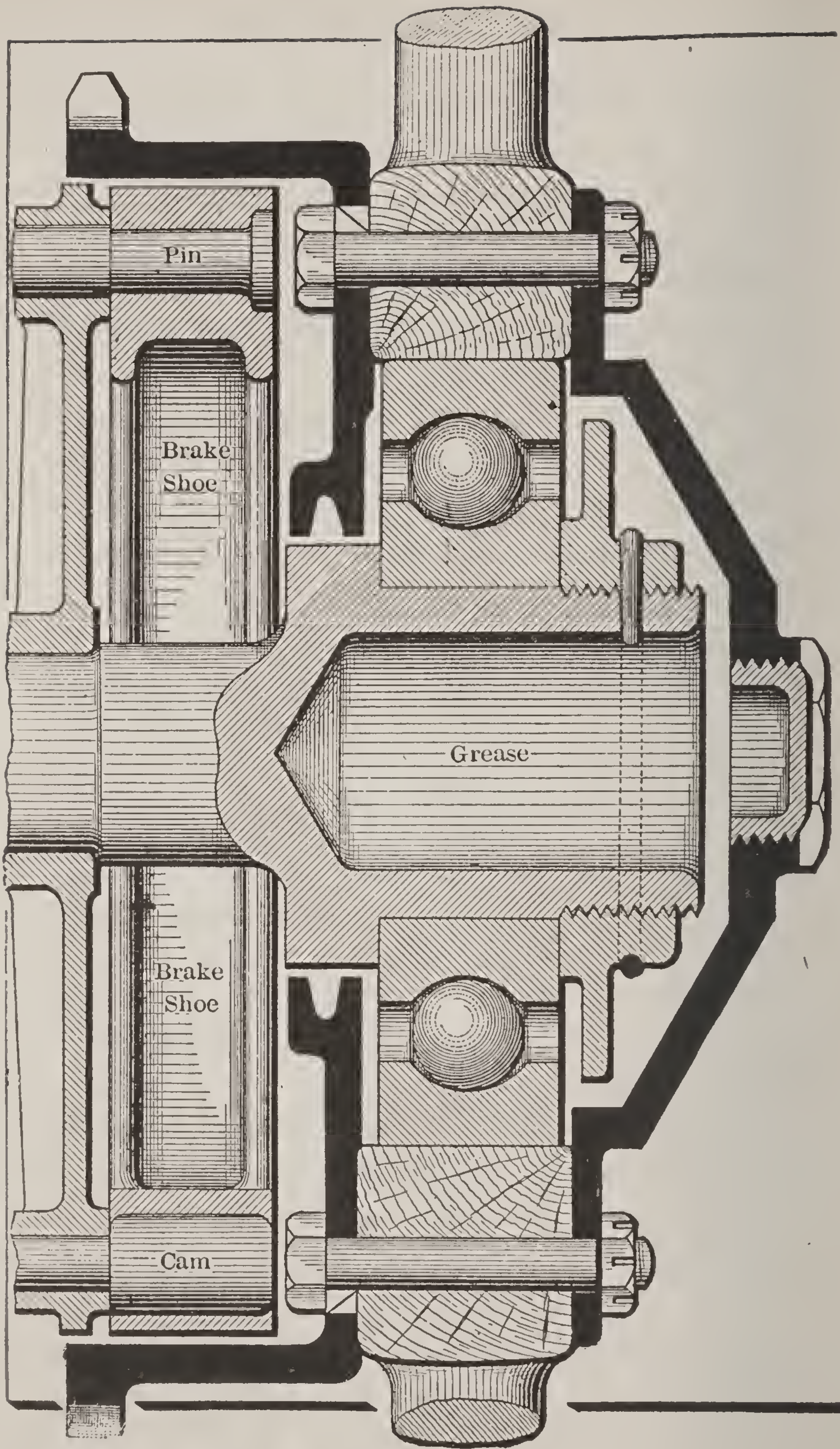


Fig. 313
Section Through Rear Wheel with Combination Brake Drum and Inner Flange

Hence, CO_2 contains 12/44 = 27.27 per cent of carbon, and 32/44 = 72.73 per cent of oxygen. From these examples it is plain that the weight of the molecule, or the molecular weight, of water is 18, and that of carbon dioxide, 44.

Wheels. The wood work of all wheels should be of selected grades of second growth hickory, or equally good growths of other hard woods. In the driving wheels the twisting moment of the motor is transmitted to the spokes of the wheels, and this torsion must be resisted by the wood at the miter, therefore, if the hub flanging is not clamped tight there is danger of the joints "working," which will soon lead to something worse. When the hub clamping bolts are tightened up they should be so pinned that they will not turn with the nuts because if the bolts do turn it will be impossible to apply sufficient pressure, and the clamping effort will be insufficient. Fig. 313 shows a hub in which the clamping bolts are prevented from turning by means of a triangular shaped extension just under the bolt heads, which engages a slot in the flange. In this hub the flange is made integral with the brake drum, which also serves for the sprocket wheel, and the torsional effort is taken by integral metal at all points, thus relieving the wood work from shock. The nuts used on the clamp bolts shown in Fig. 313 are castellated, although it is not necessary to use castellated nuts unless the flanges have to be removed, which in modern construction is

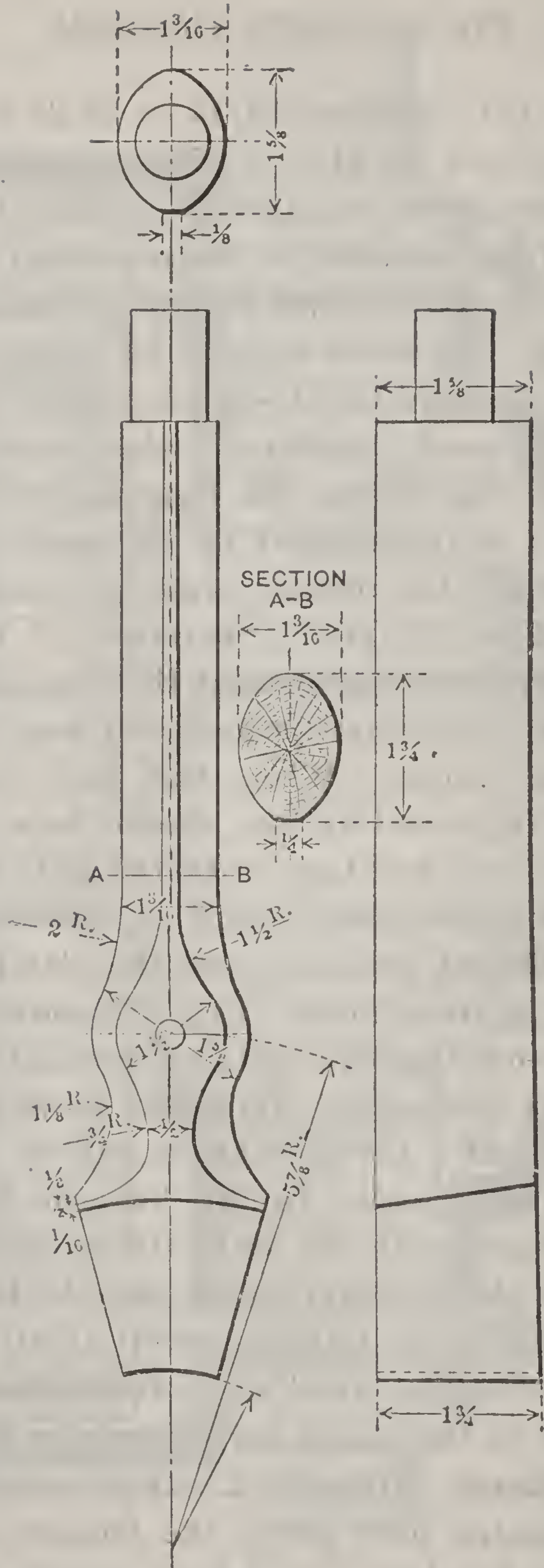


Fig. 314
Rear Wheel Spoke, Showing Proportions

the exception, rather than the rule. In ordinary practice if the wood is thoroughly seasoned, plain nuts, if screwed up tight will hold without resorting to the method so common in shop practice of riveting the ends of the bolts over the nuts. The elastic nature of the wood will serve to hold the nuts in place. Regarding spokes, a certain symmetry of contour is necessary if they are to be machine made. Fig.

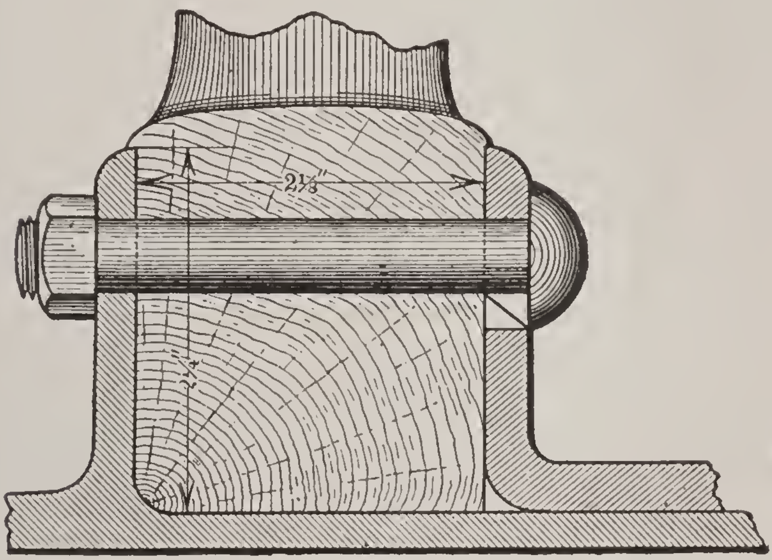


Fig. 315
Section of a Hub at the Miter Showing Depth of Flange and Method of Clamping

314 shows a spoke in which all the advantages known to wheel making are embodied, and the depth of flanging is that which experience dictates as adequate. The dimensions of the spoke are shown in detail in the cut. The brake drum is bolted to the spokes at a considerable radius, thus eliminating excess strain on the wood work.

The strength of the spoke depends in a large

measure upon its thickness in the axle plane at the hub flange, which in Fig. 314 is 1¾ in. The second point of importance is at A, B, where the largest diameter is also 1¾ in., but in the plane of the wheel instead of the axle. At the tenon engaging the felloe, this spoke is 1⅝ in., in its major diameter, which is the plane of the

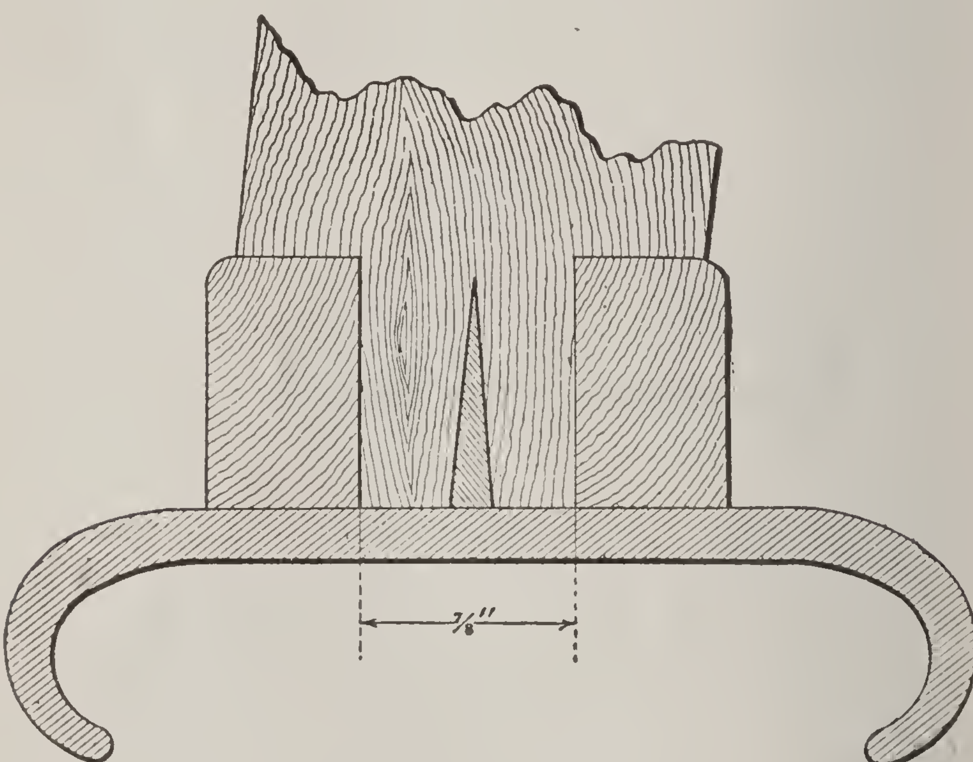


Fig. 316
Section of Felloe Depicting Tenon and Method of Wedging Which will Split the Felloe

axle, while in the plane of the wheel the minor diameter of the elliptical section is 1 3/16 in., which dimension prevails in this plane from point A, B, out to the felloe. In some types of spokes the section at the engagement of the felloe is round, and reduced gradually to the section at A, B. Fig. 315 shows a section of the

hub of another type of wheel, in which the radial depth of flanging is 2¼ in., and the axle thickness of the wood is 2⅛ in. This wheel may be used on a 60 H. P. car, and will serve as a safe example of depth of flanging, as well as a guide in fixing the shear section of the spokes for stresses induced, when cars of great power skid, provided the wheel is not dished. Fig. 316 shows the same spoke at its engagement with the felloe, indicating the manner in which the spoke is wedged into the felloe.

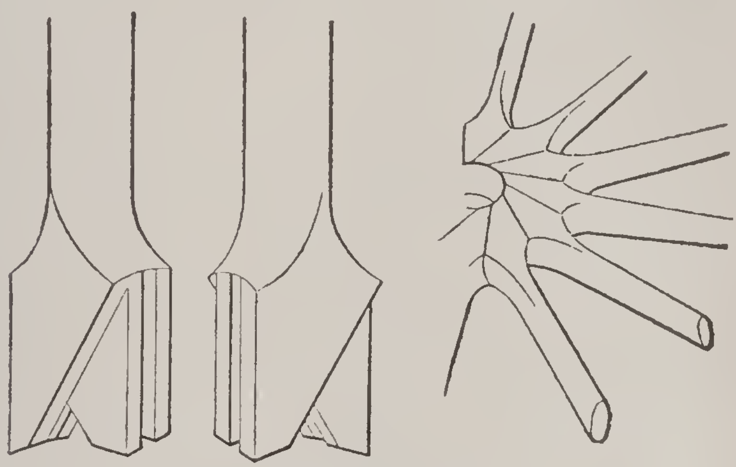


Fig. 317
Schwarz Wheel Showing Miter Joints

Figure 317 shows the Scharz type of wheel, indicating the method of overlapping the miter, thus making it possible to true up the wood work independent of the hub. Fig. 318 shows a section of the hub, spoke and felloe of a dished wheel, and it will be seen that the felloe is not in the plane of the miter, and the dish of the wheel is outward. When a car is running at a comparatively high speed rounding a curve, the outer wheels are stressed in such a

manner that the tendency is to set a dish in them exactly opposite to the dish given by the wheel maker.

The shorter the spokes are, the greater will the dishing have to be in order to insure that the spokes will be enough longer than the radial

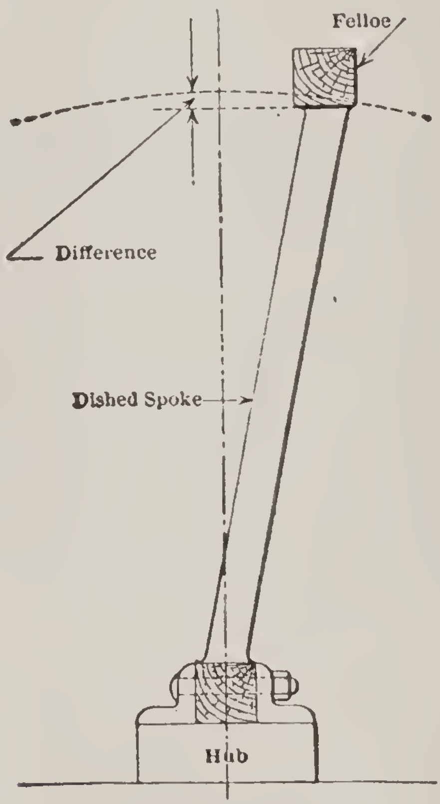


Fig. 318
Section of a Wheel Showing the Dish, Which Has Strength to Resist Skidding and Lateral Stresses

distance from the hub end of the spokes to the bearing against the felloe, to serve as members in compression, and the rim on the felloe will have to do the work. As the cut shows, the excess length of spokes marked "difference," represents the versed sine of the angle of the spokes.

Dishing transfers skidding stresses to the rim, induces compression moments in the spokes, and thus eliminates shearing moments at the flanges of the wheels, which makes it possible to reduce the width of the spokes in the plane of the axle near the hub. This will, however, necessitate sufficient strength in the stationary rim to withstand the additional strain. In automobile wheels, if the rim proper is placed over a stationary rim, as it is in demountable work, the chances of wheel trouble may come, as in ordinary carriage wheels, by what is known as "rim bending." A rim bound wheel is liable to warp and become unsafe, especially if allowed to stand in a damp place. Owing to the increasing scarcity of second growth hickory, wire wheels are coming into favor to a considerable extent, but the principal objection to their use is their liability to rust. However, there is no doubt that a high nickel steel, in which corrosion will be practically eliminated, will eventually be made for wire spokes. As to the strength of wire wheels there can be no question, provided, of course, that the steel is of good quality.

Wipe Spark. A form of primary sparking device which is in use on some gasoline motor-cars, but principally used on marine and stationary gasoline motors. A form of wipe or touch spark is illustrated in Fig. 319, in which the make and break is between a rocker arm located in the side of the combustion chamber,

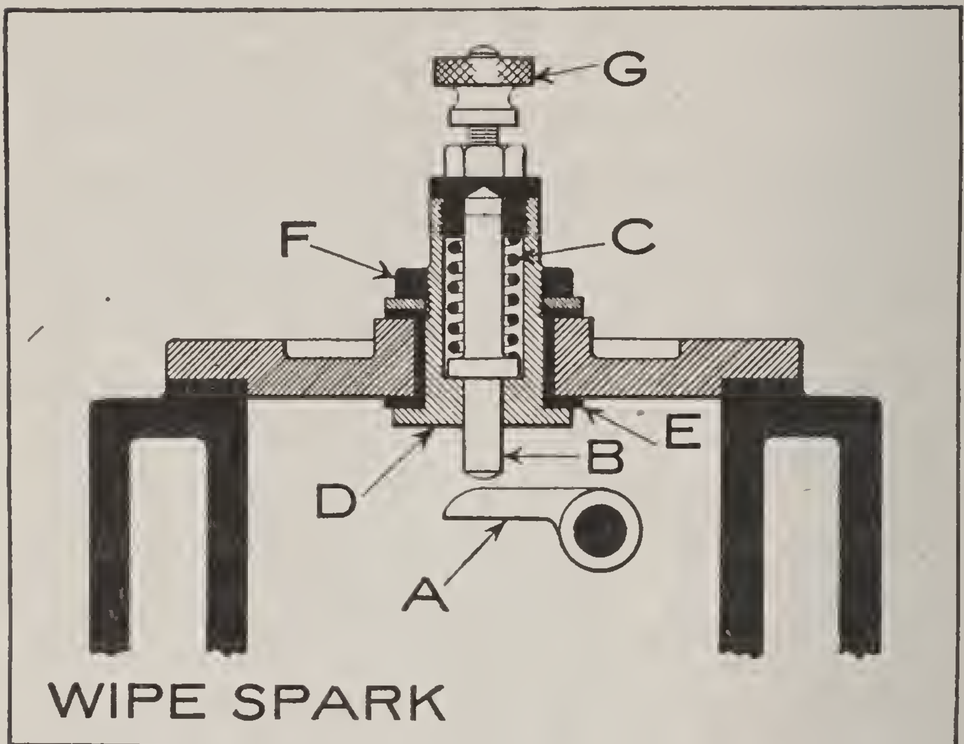


Fig. 319

A—Rocker contact arm.
B—Spring-actuated plunger.
C—Coil spring.
D—Insulated bushing.
E—Mica insulation.
F—Lock nut.
G—Terminal nut.

TABLE 19.

RESISTANCE AND CARRYING CAPACITY OF BARE AND INSULATED COPPER WIRE.

B. & S. Gauge.	Diameter in inches.	Ohms per thousand feet.	Carrying Capacity in Amperes.	
			Insulated.	Bare.
6	.162	0.411	65	65
7	.144	0.519	56	56
8	.128	0.654	46	46
9	.114	0.824	39	39.2
10	.101	1.040	32	32.5
11	.091	1.311	27	27.8
12	.081	1.653	23	24
13	.072	2.084	19	19.6
14	.064	2.628	16	16.3
15	.057	3.314	10	13.9
16	.051	4.179	8	12.0
17	.045	5.269	6	9.8
18	.040	6.645	5	8.1
19	.035	8.617		7.0
20	.032	10.566		6.0

and a spring plunger immediately above the end of the arm, and in the center of the cylinder head. The reference table given in connection with the drawing will explain the construction clearly.

Wiring for Ignition Circuits. Multi-cylinder gasoline motors may have the wiring of their ignition circuits arranged in various manners, as follows:

TWO-CYLINDER MOTOR. Single-coil, with the two spark plugs in series with each other. A four terminal coil is necessary to use with this arrangement.

Duplex-coil, with the two spark plugs independently connected to the sceondary winding of the coil, one end of each secondary wire being grounded to the frame or motor.

FOUR-CYLINDER MOTOR. Two coils, with each pair of spark plugs in series with each other. Two four-terminal coils are necessary with this arrangement.

Four coils, with the four spark plugs independently connected to the secondary winding of the coil, one end of each secondary wire being grounded on the frame or motor.

The wiring for the ignition circuit of a four-cylinder motor is illustrated in Fig. 320. The commutator, quadruple coil, spark plugs, and duplex battery system are plainly shown.

Wiring Troubles. In a single-cylinder motor the complete breakage of a wire or the loosen-

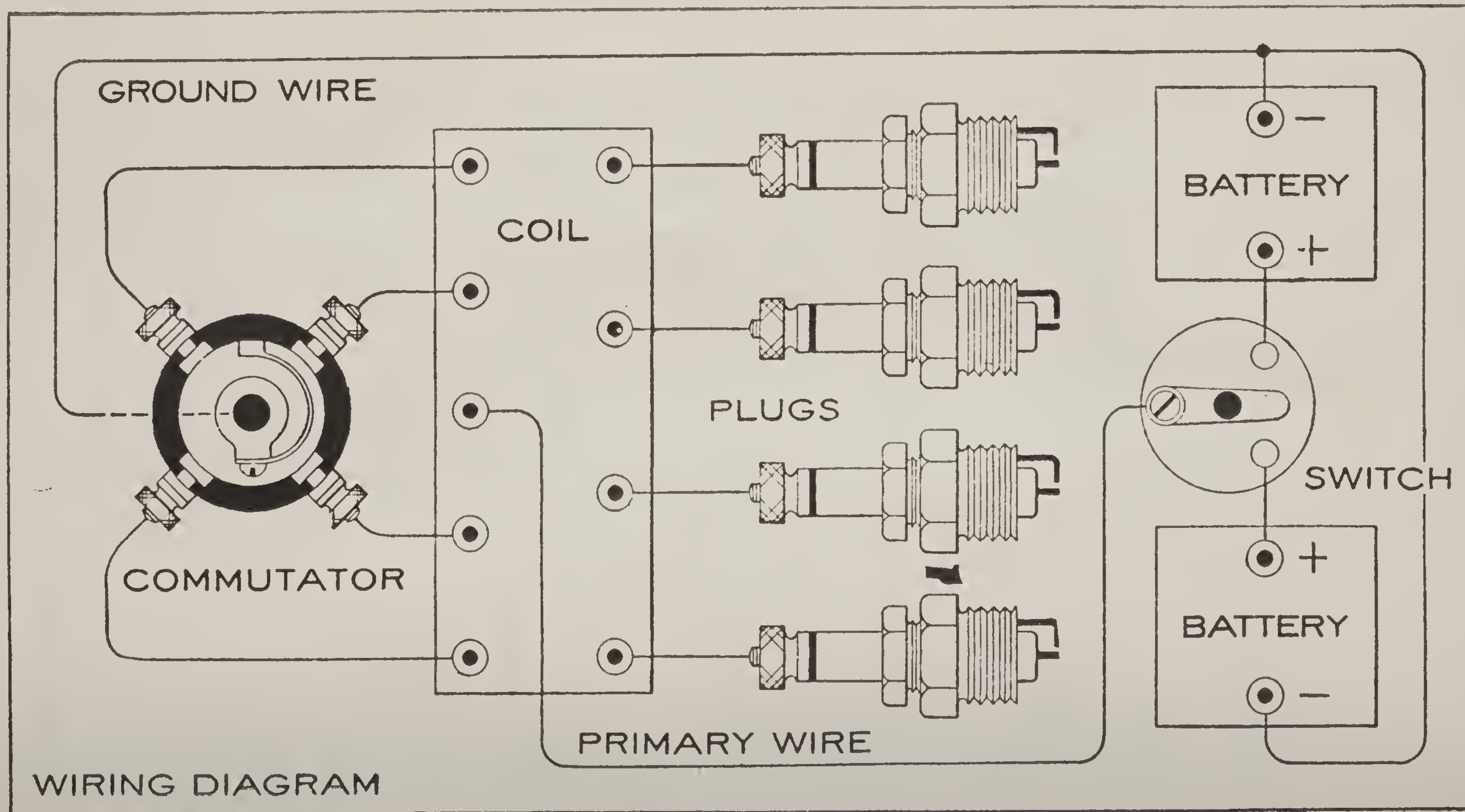

GROUND WIRE
COIL
BATTERY
−
+
PLUGS
SWITCH
COMMUTATOR
BATTERY
+
−
PRIMARY WIRE
WIRING DIAGRAM

Fig. 320

ing of a connection, or the displacement of the wire leading to the spark plug will cause an instant stoppage of the motor. In a multi-cylinder motor such an accident will probably slow the car, and cause one cylinder to miss, with the result probably of explosions in the muffler.

Wire-Drawing of Mixture in Carbureters. Frequently it is observed that the intake to the carbureter is so restricted that noise issues, and a little further investigation in such cases will disclose, in all probability, that wire-drawing is one of the ills. It is not alone the noise that is objectionable in such cases; the power of the motor will be less, due to the restriction which has the effect of reducing the weight of mixture that enters into the cylinders, and the power of a motor is undoubtedly proportional to the weight of mixture that enters the cylinders, assuming, of course, that the same is in acceptable form, and that it is completely burned. True, there must be a depression in the carbureter in order that there will be a difference in pressure, so that gasoline will be sucked into the train of air; equally true, it is of the greatest importance to have the depression as low as possible in order that the power of the motor will be a maximum. If the depression is but slight, provided the carbureter is properly designed, the amount of fuel entrained will be adequate for the purpose. If, on the other hand, the depression is very large and

holds considerable fuel, it will soon be found to be wasteful of the liquid.

Wood Alcohol for Cooling. The idea in using alcohol in the cooling system is to get away from the use of water. In other words, the freezing point of the liquid used must be lowered to prevent freezing in the system, and the consequent disruption, which is bound to follow if the solution solidifies, since then bulk increases and is irresistible. It would seem quite out of place to purchase alcohol for the purpose, were the same half water, since water is to be displaced in the system. In the purchase of alcohol then, for the purpose, care should be exercised to order the same as free from water as possible.

According to the United States Pharmacopœia, "alcohol" should hold 91 per cent alcohol and 9 per cent water, "proof spirits" only holds 55 per cent of alcohol, and "absolute alcohol" will run about 98 per cent of alcohol with 2 per cent water. An alcohol-meter reads Zero (o) in water and 100 if there is no water present. The alcohol-meter, then, shows by its workings the percentage by volume of alcohol present.

Because of the high price of grain alcohol, the formula for which is C_2H_6O, it is customary to use wood alcohol, the formula for which is CH_4 O, and because of this difference in the composition of the two grades of alcohol, the alcohol-meter should be purchased to use with

wood alcohol on the one hand, or with grain on the other, depending upon the kind of alcohol taken in any given case.

Xardell Muffler. In the Xardell muffler a vacuum is employed to create a suction upon the exhaust gases coming from the engine. The muffler consists of an elongated cylinder divided into two compartments, the smaller perfectly air-tight acting as the vacuum chamber; the second, or large compartment, designed to silence the exhaust, divides the gases into innumerable small jets and finally delivers them through an open port. According to test, with a pressure gauge attached to the muffler and the vacuum gauge attached to the vacuum chamber, the exhaust from a four-cylinder motor with 5-inch bore was turned through it with a result that no pressure was shown under gauge attached to the muffler, and the pulsating vacuum indicated on the gauge attached to the vacuum chamber. This experiment apparently showed that immediately after the explosion the vacuum formed in the muffler relieved itself by drawing gases from the exhaust pipe, which naturally worked against any back pressure on the motor.

Zero—Absolute. The freezing point was chosen as the zero point of the centigrade scale. When the Fahrenheit scale was invented, the zero point of the thermometer was placed 32° below the freezing point, as that was the lowest temperature that could then be obtained, and

it was supposed that it was impossible to obtain a lower one. From the results of experiments and from calculations, however, it has been concluded that at 461.2° F. below zero, or 493.2° F. below the freezing point, there is absolutely no vibration of the molecules and consequently no heat. This is therefore called the absolute zero, and all temperatures reckoned from this point are called absolute temperatures. Absolute zero has never been reached, the lowest recorded temperature being in the neighborhood of —400° F.

STARTING AND LIGHTING DEVICES

Self-Starters. One of the most important of the late developments in motor-car construction is the installation of mechanical starting devices, by which a powerful impulse is given to the motor before the explosions in the cylinder occur. Thus cranking by hand is eliminated, driving is made more practicable for women, and the safety, convenience and personal comfort of the motorist are increased.

Self-starting systems are of two principal types, operated (1) by compressed air, and (2) by electricity. Most cars of recent construction are now equipped with one of these two systems.

Compressed Air Starters. In a typical air-pressure system the motor is operated with compressed air until regular explosions take place in the cylinders; the air supply is then shut off and the motor takes up its regular operations.

The parts of this self-starter are as follows (see Fig. 321): 1, a high-pressure, four-cylinder air pump, for compressing air in a storage tank; 2, a pipe for carrying air from pump to storage tank; 3, a pipe which carries air from

tank to push valve on the dash; 4, a pipe which carries compressed air from the push valve to the "distributor"; 5, pipes through which air is carried from the distributor to the various cylinders; 6, poppet valves—one in each of the cylinders—by means of which compressed air from the distributor is admitted to the cylinder ready for the working stroke; 7, a pressure gauge on the dash, which keeps the operator informed of the amount of compressed air in the storage tank; and 8, a pump clutch, operated by a foot pedal, which throws the gears of the air pump into mesh.

The air pump in this system is driven by a silent drive chain from the water pump shaft, and operates only when the gears are thrown into mesh by pressing the pump clutch foot pedal. It is a simple device for compressing the air and delivers a steady flow to the storage tank. A pressure of 50 lbs. in the tank will start the motor under ordinary conditions, but it is advisable to keep the pressure at about 150 lbs.

The storage tank is carried beneath the body of the car and is tested for a pressure of 600 lbs. to the square inch.

The dash push valve opens the air line from the storage tank to the distributor and simultaneously opens the cylinder valves so that air coming from the distributor through the pipes shown in Fig. 321 has ready access to the cylinders. When the foot is removed from the

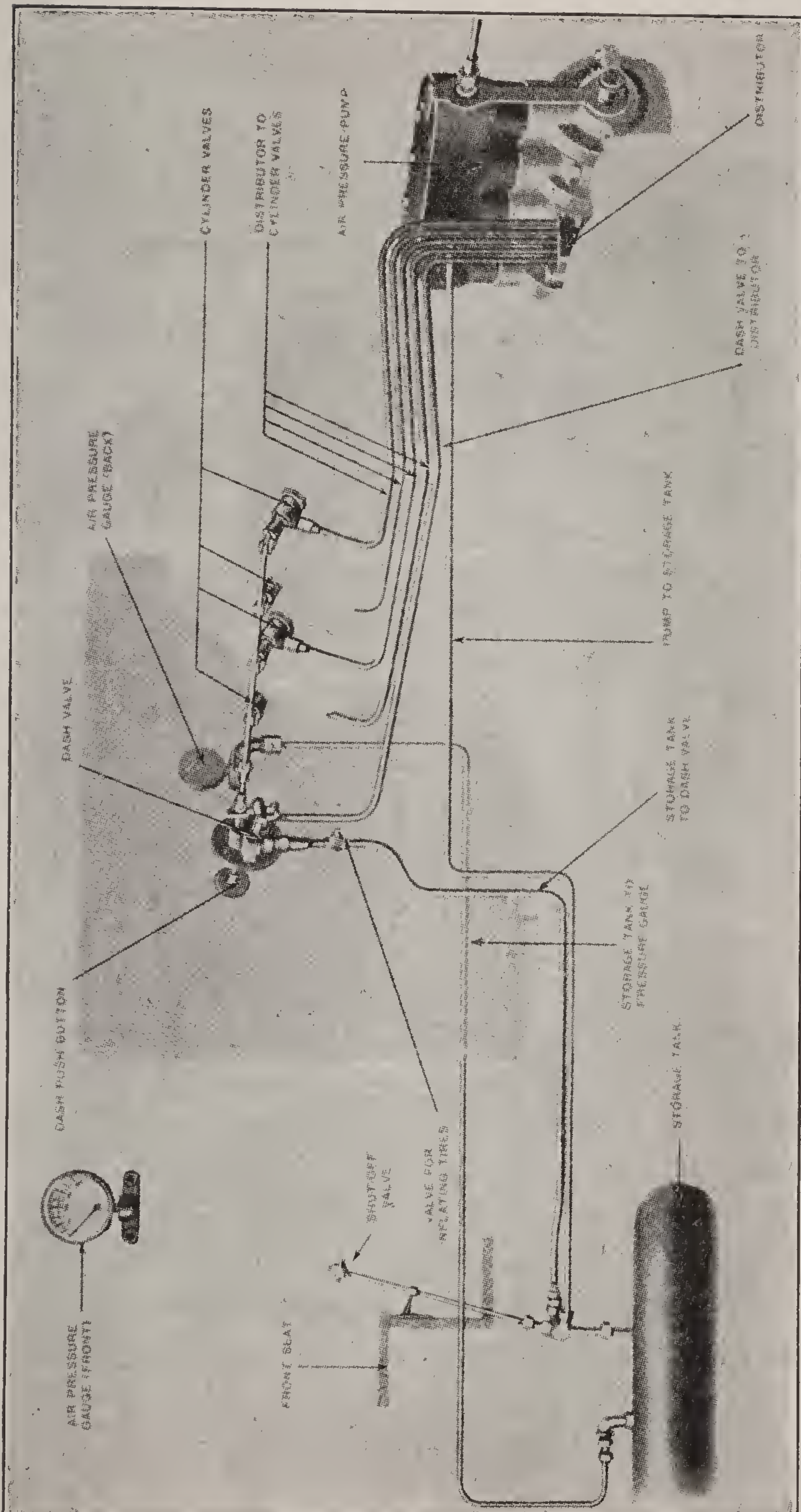


Fig. 321—Chalmers Air Pressure Starting Mechanism.

dash button, both the escapement valve and the cylinder valves are closed automatically and the compressed-air starter is shut off from the motor.

The distributor sends charges of compressed air into the cylinders ready for the working stroke, in their order of firing. It is geared to the pump and magneto shaft and positively timed for feeding air.

This type of self-starter is also used for the purpose of inflating tires by means of a special shut-off valve and hose.

The principle of compressed-air starters is to admit air under 50 to 150 lbs. pressure from a generous reservoir directly to the motor cylinders at the beginning of each expansion stroke. This operates the motor without affecting the mixture in the cylinders. When running under air pressure the admission of the compressed air at almost the moment of the spark operates the same as an ignition, causing a rise of pressure in the cylinder. After it has performed its work this pressure is released by the exhaust valve in the same manner as the burned gases are released when the motor is running under its own power.

Electric Starters and Lighting. The use of an electric starting device in connection with the electric lighting system is regarded by many as the ideal plan for the automobile. A type of this system, used on many cars, is found in the Gray & Davis 6-volt electric starter, illus-

trated in Fig. 322. This, it is claimed, will start any engine, even the 5x7 6-cyl. motor.

This system comprises two units: 1, the starting motor; 2, the dynamo for charging

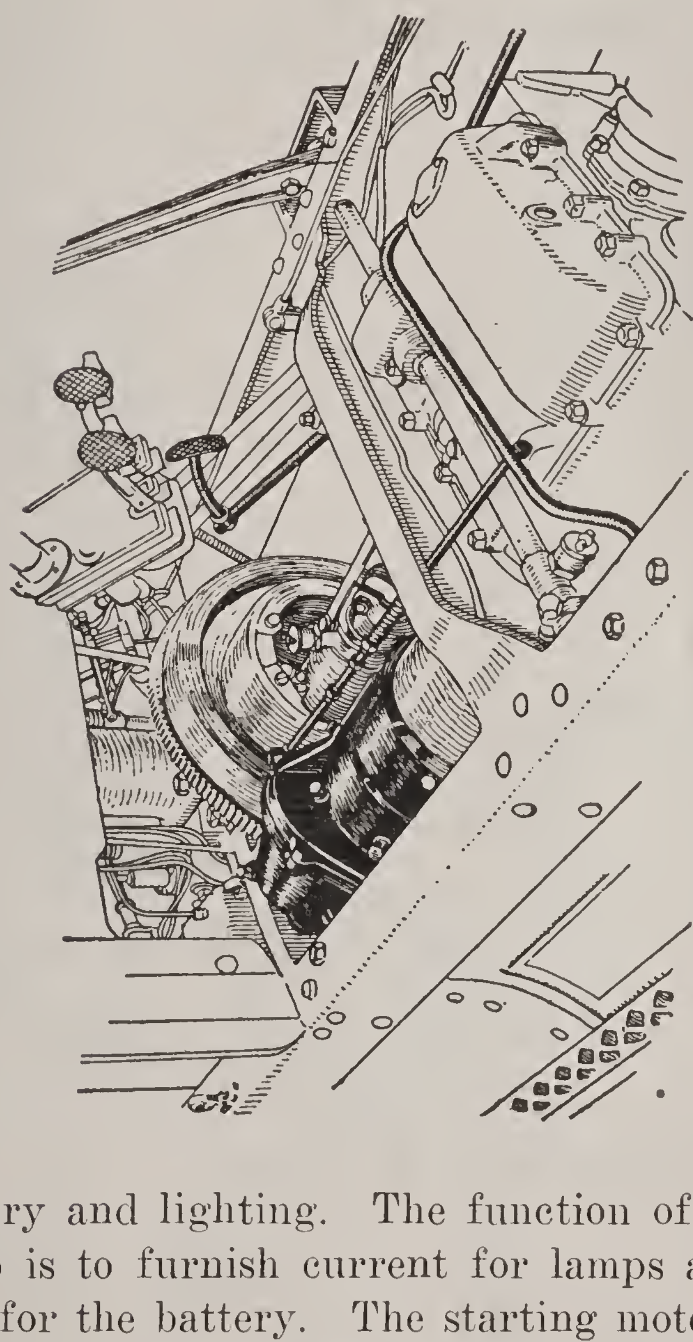


Fig. 322—Gray & Davis Electric Starter on Car.

battery and lighting. The function of the dynamo is to furnish current for lamps and current for the battery. The starting motor starts the engine. This motor is connected with the flywheel by gears, and when a starting pedal is

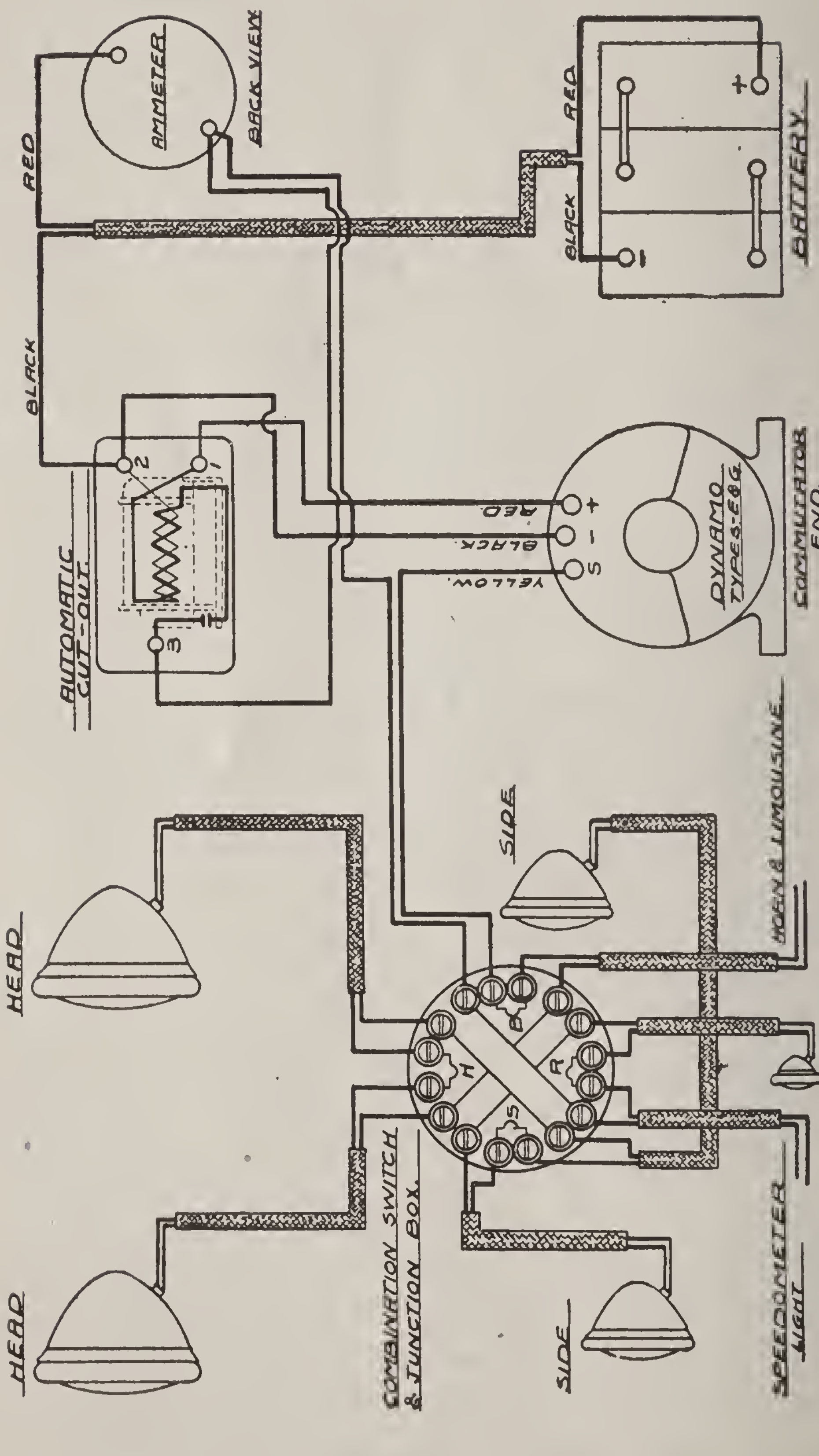


Fig. 323—Wiring Diagram G. & D. Dynamo System.

pressed the motor turns the flywheel and crankshaft and keeps turning until the engine "picks up." The starting motor then automatically ceases to operate.

The dynamo system includes the following: 1, a constant-speed dynamo, driven from the engine or jackshaft by gear or a silent chain; 2, a governor, to take care of the varying speed of the engine; 3, an electric cut-out, to disconnect the dynamo from the battery when running below the charging speed; 4, a battery to operate the lights when the dynamo is not running at the necessary speed or when the engine is stopped. This battery may also be used for firing the engine.

1. The dynamo is of the compound-wound type, designed to run at a constant speed of 1000 revolutions per minute. The system is so wired that the series field is carrying current only when the lights are burning. See Fig. 323.

2. The governor is of the simple, centrifugal type, but operates a friction clutch of new design. In operation the clutch slips just enough to hold the dynamo speed always at 1000 r. p. m., whether the engine speed corresponds to a car speed of 13 or of 60 miles an hour.

3. The electric cut-out consists of an electro-magnet with a compound winding, the fine wire part of which is connected across the dynamo terminals. Its function is, as stated, to disconnect the dynamo from the battery when the engine is running very slowly or is at rest.

If an automatic switch of this nature were not in the circuit the battery would discharge through the dynamo when the dynamo was no longer maintaining charging voltage.

4. A battery rated at 6 volts, 80-ampere

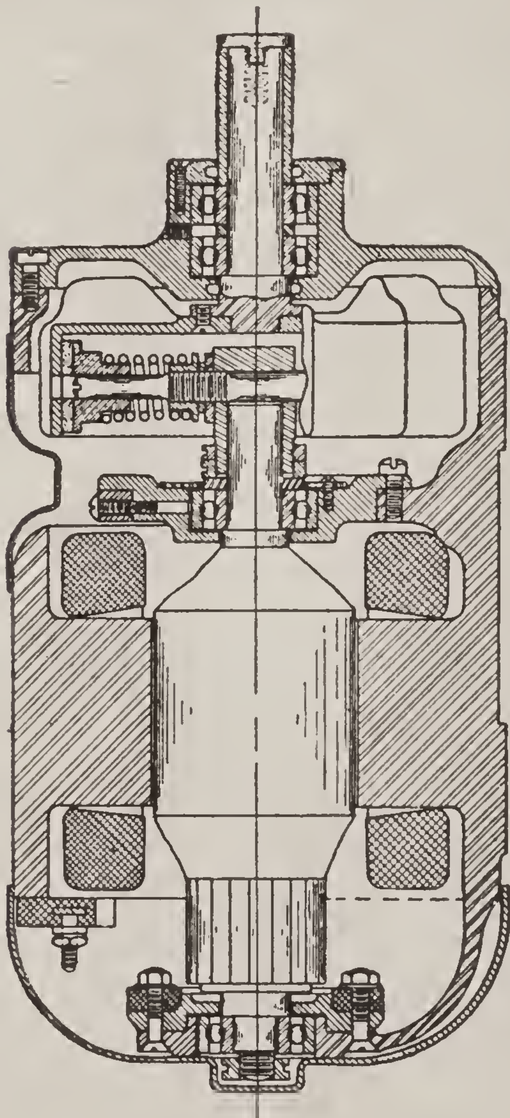


Fig. 324—G. & D. Type "G" Dynamo. Outline Showing Dynamo and Governor Mechanism.

hour capacity at a discharge rate of 8 amperes is furnished with this system sufficient to carry the full lamp load for ten hours or the side and tail lamps for thirty hours. The arrangement

of the switch connections is such that the dynamo operates as a shunt-wound machine while charging the battery and as compound-wound when supplying the lamps directly. This gives the battery a tapering charge.

The wiring for this system is plainly shown in the accompanying diagram. See Fig. 323.

The Rushmore Engine Starter. The Rushmore electric starting motor, shown in Fig. 325, acts directly on the flywheel without intermediate gears, a pinion keyed fast on the motor shaft meshing with a gear on the flywheel rim. This pinion is normally out of engagement. The closing of the starting switch causes the pinion automatically to engage the flywheel gear before the armature starts rotating. As soon as the engine picks up, the pinion automatically slides out of mesh, and remains out no matter how long the starting switch is held closed. There is no mechanism except the starting motor itself and the starting switch.

When the starter is not in use the armature is held normally out of line endwise with the pole pieces by means of a compression spring contained in and acting against the hollow armature shaft. Magnetic pull is employed to engage the pinion. The foot button starting switch has three contacts. At the first pressure upon the button the armature is drawn into the field with great force while rotating slowly so that the pinion teeth will engage. After the gears are fully engaged the third

contact applies the full force of the battery to turn over the engine.

The motor is series wound and produces a strong torque on starting. As soon as the en-

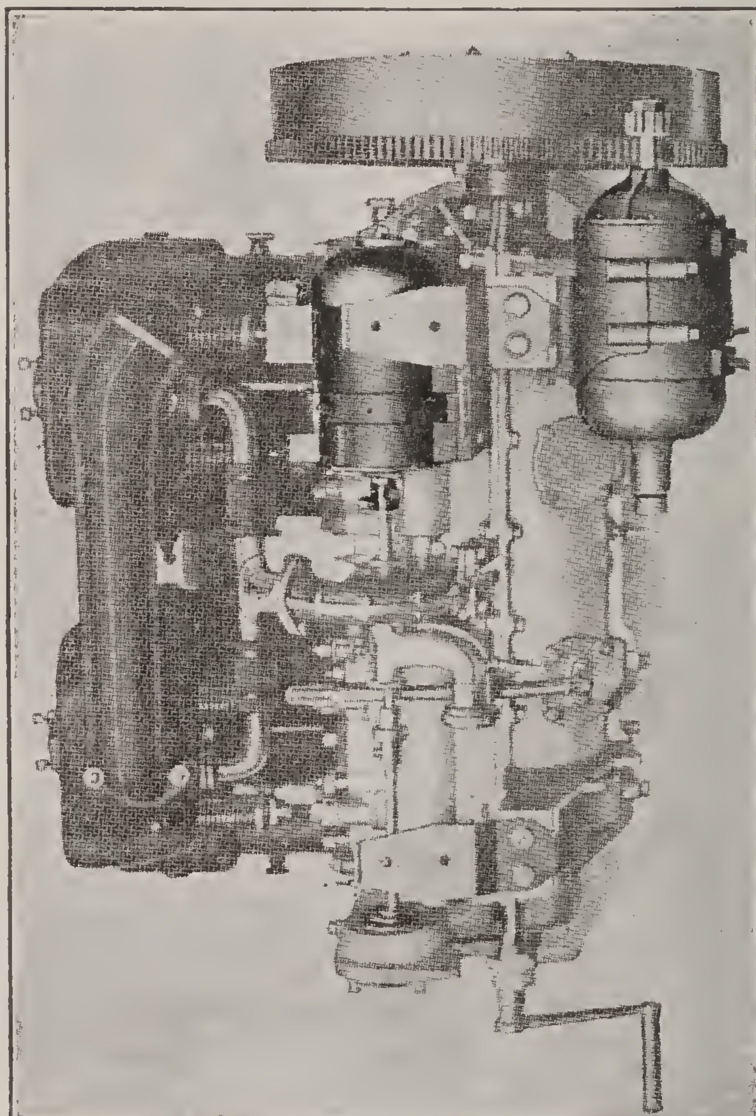


Fig. 325—Rushmore Dynamo and Starter on Simplex Engine.

gine picks up, the accelerated speed causes the counter electro-motive force in the motor to reduce the current flow to a value too small to hold the armature in line with the pole pieces against the end pressure of the spring. The

pinion then slips out of mesh and remains out, even with the circuit closed, because the current required to run the motor free is too small to overcome the spring. The armature will not again move endwise into its working position until it has stopped and the switch is again closed. The turning force developed at the flywheel rim is rated at over 400 lbs., suffi-

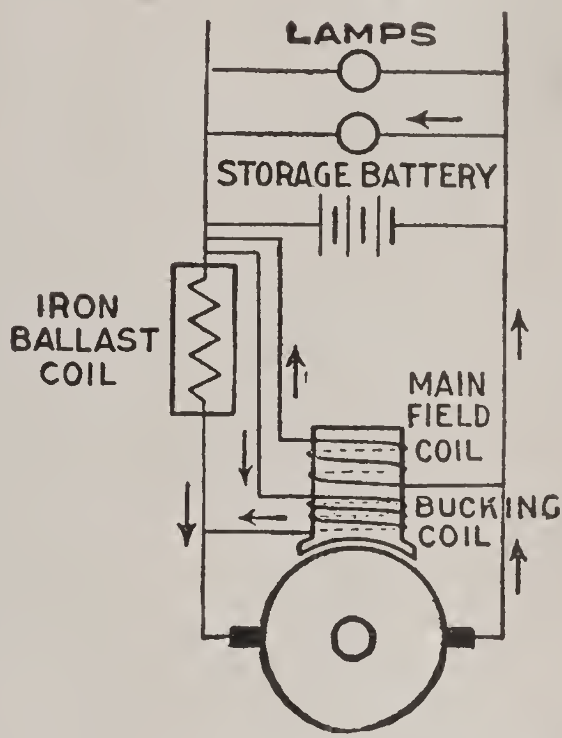


Fig. 326—Diagram of Rushmore Lighting System.

cient to start the largest engine with ease. The motor is wound for a 6-volt battery.

Rushmore Lighting System. Essential elements of this system are: 1, the dynamo; 2, storage battery, 6-volt, of 80 to 160 ampere hours capacity, depending upon size of the headlights; 3, switch and terminal block on

dashboard, which simultaneously switches the headlights on or off and switches the ballast coil in or out of circuit; 4, wiring and circuit switches for small lamps.

Briefly the action of the dynamo is to reduce the strength of the field magnet at high speeds by means of counter excitation produced by a few turns of magnet wire, called a "bucking coil," on the field poles. The amount of current passing through this bucking coil is determined automatically by the varying resistance of a small coil of iron wire, called the "ballast coil," which is made in the form of a cartridge fuse and carried in clips on the switchblock in the main line between the dynamo and the battery. See Fig. 326. The effect of controlling the bucking coil by the current output is to produce an approximately constant current at the higher speeds.

U. S. L. Electric Motor Generator. In the system employed by the United States Light & Heating Co., with which many automobiles are now equipped, an electric motor generator is an integral part of the gasoline motor and furnishes current for starting and lighting. The system includes, besides the motor generator, an automatic current regulator, an oil switch and a storage battery.

The motor generator comprises a set of field coils, armature and commutator and brush ring. These parts replace the flywheel of the gasoline motor, being attached to the crank-

shaft in its stead. They are inclosed in an aluminum case and dust ring.

When a starting button is pressed down, the current from the storage battery starts the

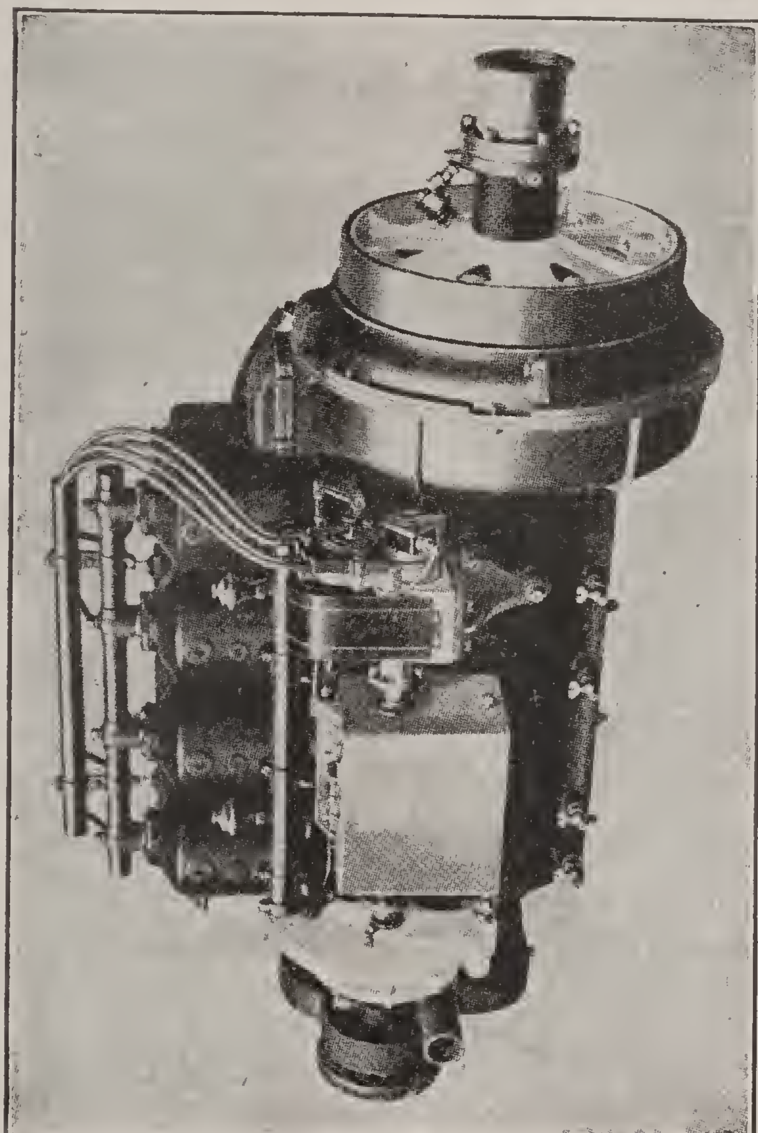


Fig. 327—U. S. L. Gasoline Electric Motor Complete.

motor generator. This revolves the crankshaft of the gasoline motor. With the switch of the ignition coil in either magneto or battery position, the gasoline explosions commence. The foot starting button is then released, when the

electric motor automatically changes into an electric generator. As the speed of the gasoline motor increases, the generator gradually begins charging the battery, restoring the current discharged during the starting operation.

An automatic regulator, controlling the current to the battery, is located in the center of the dash. It has a charging indicator, the function of which is to show that the circuit is closed at the proper time, or at a speed of 12 to 14 miles an hour, and that the circuit is open when the car speed drops below about 10 miles an hour or the motor stops altogether. The regulator consists of a compound-wound magnet and a variable resistance with magnet bar and contacts for controlling field current in the generator.

The oil switch is included in this system to change the electric motor into an electric generator upon the release of the starting button.

This and other electric starting devices are designed for the sole purpose of starting, and not of running the car. There is often a strong temptation, however, to make them perform excess duty. This should be avoided as much as possible. If a driver has occasion to make repeated demonstrations of the starting feature without running the car, he should always allow the gasoline motor to run for at least a minute or two at a fair speed—800 or 1000 r. p. m.—between starts. This will replace the current required for starting.

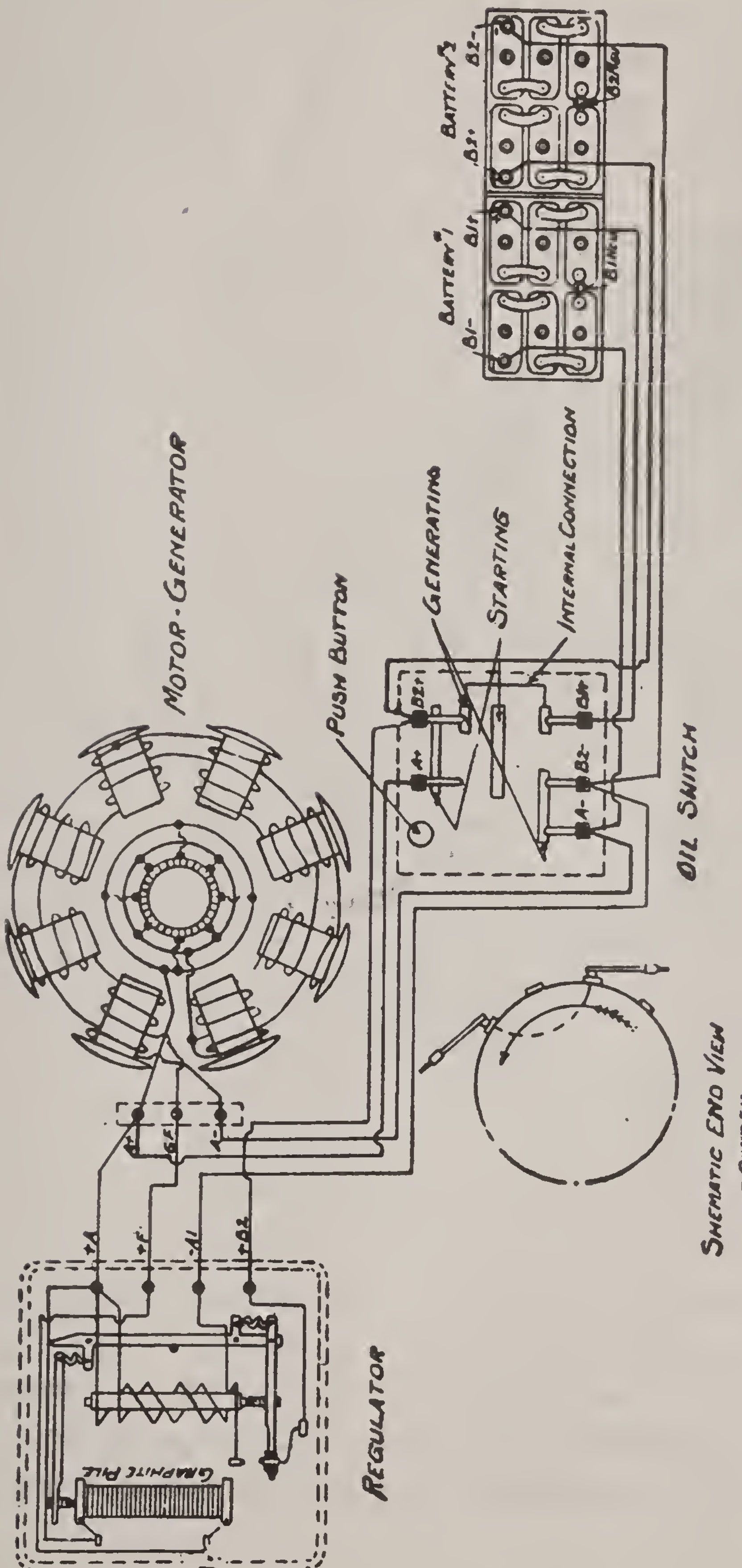


Fig. 328—Wiring Diagram of U. S. L. Starting System.

Delco Cranking and Lighting System. The Delco motor-generator is another device extensively used for starting the gasoline motor and supplying current for lighting purposes.

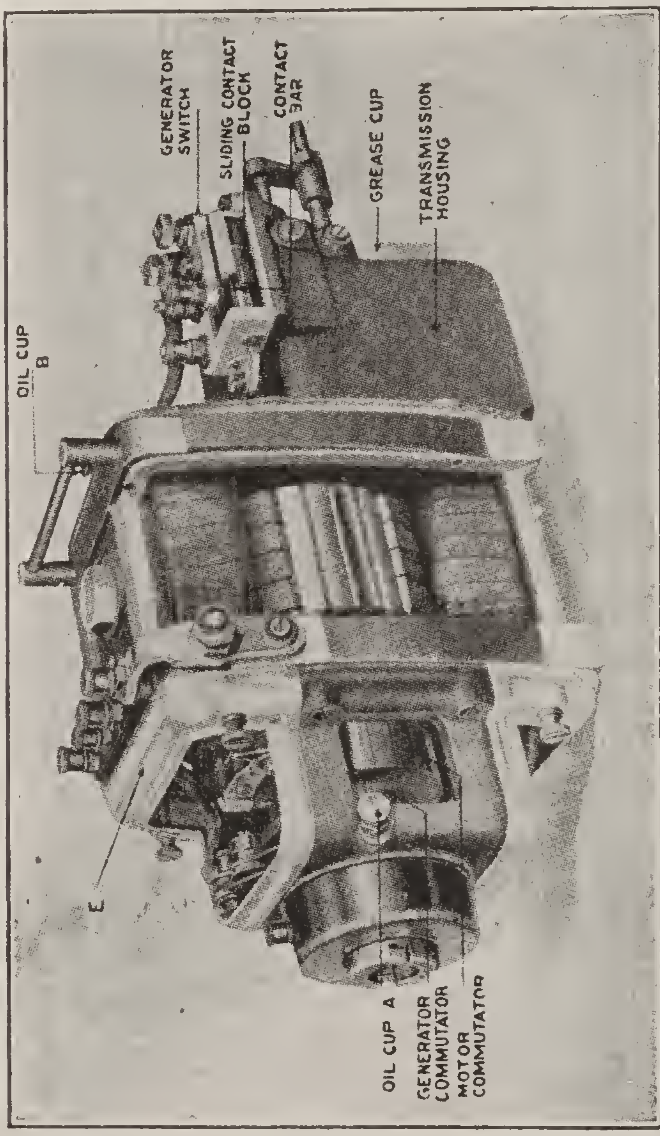


Fig. 329.
Delco Motor-Generator for Cranking and Lighting, with parts cut away to show construction.

In its first function it is a series-wound motor with a spur gear pinion upon the end of the armature shaft nearest the flywheel. Interposed between this pinion and the gear teeth cut in the periphery of the flywheel is a pair

of gears adapted to slide along and revolve upon an intermediate shaft. The sliding action causes one of these gears to engage with the motor pinion, while the other meshes with the gear teeth upon the flywheel.

A positive, one-way clutch is incorporated as part of the intermediate gear, for the purpose of permitting the engine to run ahead of the motor during the short time that the gears may be enmeshed while the engine is running under its own power.

In performing its function as a charging unit the motor-generator resolves itself into a shunt-wound generator, driven from the engine by means of a shaft extended from the camshaft gear housing. The generator is driven at crankshaft speed, and in order to compensate for the higher ratio when the unit is in starting relation to the engine, a second one-way clutch is provided adjacent to the forward housing. This clutch permits the armature to run ahead of the driving shaft.

A voltage regulator, controlling the amount of current flowing from the generator to the storage battery, and a cut-out relay are included in the Delco system. The function of the latter unit is to close the circuit between the generator and the storage battery when the generator voltage is high enough to charge the storage battery. It also opens the circuit as the generator slows down and its voltage becomes less than that of the storage battery, thus

preventing the battery from discharging back through the generator.

In operating the Delco starting device on a typical car, when the push button on the lighting switch box is depressed, it closes a circuit and two things are accomplished: Current flows from the storage battery through a magnetic latch coil circuit and also flows through the generator windings, causing the armature to rotate slowly so that the starting gear will mesh into the motor pinion and with the teeth on the flywheel. The energizing of the magnetic latch coil causes the mechanism which operates the starting transmission and the generator switch to be linked to the clutch pedal shaft and consequently to be thrown into operation by the depression of the clutch pedal.

When pushing forward on the clutch pedal to throw these gears into mesh, if it should happen that they are in such a position that the ends of the teeth in the clutch gear come against the ends of the teeth in the flywheel, instead of the teeth of one sliding between the teeth of the other, the operator should be careful not to try to force them. Simply let the clutch pedal come back a little and try again. By that time they will probably have changed their relative positions sufficiently to allow the teeth to mesh properly.

501 Front axle with yokes and spring supports.
502 Right steering knuckle.
503 Left steering knuckle.
504 Front springs.
505 Front spring clips with cross pieces.
506 King bolts and nuts.
507 Inside annular front bearing.
508 Outside annular front bearing.
509 Nuts for spindle of knuckle.
510 Lock washers for nuts on spindle.
511 Steel dust washers.
512 Felt dust washers.
513 Front connecting rod complete with adjusting ends.
514 Adjusting end right hand thread front.
515 Adjusting end left hand thread front.
516 Cone screws, nuts and brass cones for front adjusting ends.
517 Rear connecting rod complete, adjusting end and ball rod adjuster.
518 Adjusting end rear connecting rod.
519 Cone screws, nuts and brass cones for rear connecting rod.
520 Ball rod adjuster with bolts.
521 Ball rod with adjusting ring.
522 Right hand front connecting rod lock nut.
523 Left hand front connecting rod lock nut.
525 Bolts for holding spokes in hubs.
526 Spring clip holders.
527 Hardened washer for knuckles.
528 Ball rod brasses.
529 Rear connecting rod lock nut.
530 Front wheels with rims without tires and without bearings.
531 Tires front and rear.

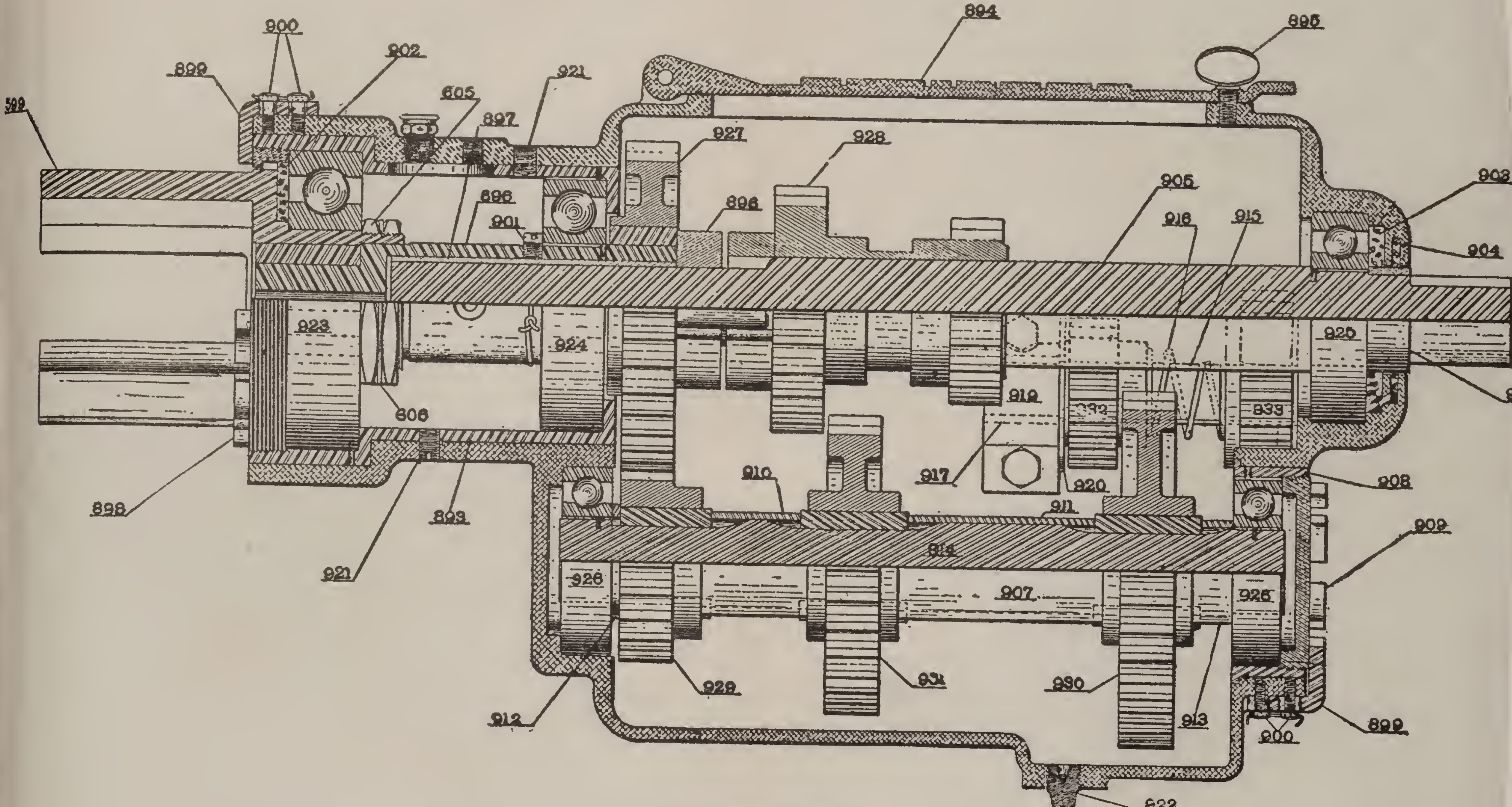
532 Washer inside front dust cap for holding in outside bearing.
533 Front dust caps.
534 Rear dust caps.
535 Rear wheels with rims without tires and without bearings.
536 Outside rear annular bearing.
537 Inside rear annular bearing.
538 Sleeve on spindle rear axle.
539 Locknuts for rear wheels.
540 Lock nut washers for rear wheels.
541 Dog clutches.
542 Inner axles, right and left, same length.
544 Rear outside axle including top bearing of driving shaft, hub brake supports, rear springs, supports, screw cover for gear case, auxiliary bearing caps and truss rod.
545 Differential gear complete.
546 Large bevel gears.
547 Bevel pinion.
548 Annular bearings on differential.
549 Large nuts on differential for adjusting bearings.
550 Lock washers between adjusting nuts on differential.
551 Ball thrust bearing.
552 Nut back of ball thrust on differential.
553 Spur gear inside of differential.
554 Spur pinions inside of differential.
555 Bolts holding spur pinions in differential.
556 Holders for rear spring bumpers.
557 Rubber for bumpers.
558 Lock springs for dust caps.
559 Auxiliary bearing caps inside of gear case.
560 Spring hooks for large and small brake bands.
561 Large brake bands.
562 Small brake bands.

563 Hardened steel wearing plates for large and small brake bands.
564 Cam shaft for large brake band.
565 Cam shaft for small brake bands.
566 Spiral springs for large and small brake bands.
567 Levers on cam shafts.
568 Supporting pins for large and small brake bands.
580 Truss rod under rear axle with two nuts.
581 Cam shaft washer for large and small brakes.
582 Right hand front fender with irons.
583 Left hand front fender with irons.
584 Rear fender with irons.
585 Driving shaft with nut for pinion and cross pin.
586 Annular bearing on driving shaft back of pinion.
587 Annular bearing at front end of driving shaft.
588 Adjusting nuts on driving shaft.
589 Lock washer for adjusting nuts on driving shaft.
590 Swivel hub front bearing support for driving shaft without bearing.
591 Sheet steel dust washer over bearing and screws for same.
592 Felt dust washer over bearing.
593 Swivel yoke.
594 Swivel yoke bracket.
595 Hinged tee for swivel yoke.
596 Steel bar through swivel yoke bracket.
597 Special cap screw holding swivel yoke to top driving shaft bearing.
598 Three-eighths cap screw holding top bearing of driving shaft to tubular casing.
599 Universal joint, main hardened steel portion.
600 Squares in universal joint.
601 15-16 inch cross pin through driving shaft.
602 Sleeve for universal joint.
603 Rawhide cover for universal joint.
604 Cap screws in universal joint sleeve.

605 Nuts on universal joint.
606 Washer between nuts on universal joint.
607 Fender brackets riveted to frame.
608 Fender studs for runningboard.
609 Pressed steel frame with parts riveted on including front and rear spring loops.
610 Front spring loop, right.
611 Front spring loop, left.
612 Rear spring loop, right.
613 Rear spring loop, left.
614 Front spring brackets.
615 Rear spring brackets.
616 Brake and clutch shaft brackets.
617 Rear springs.
618 Rear spring links.
619 Front spring links.
620 Bolts and nuts for front and rear spring links.
621 Bolts and nuts for attaching front spring to loop and rear spring to bracket.
622 R. H. front runningboard supporting iron.
623 L. H. front runningboard supporting iron.
624 Rear supporting irons for runningboard.
625 Right hand runningboard with brass edge strip.
626 Left hand runningboard with brass edge strip.
627 Brass edge strip around runningboard.
628 Rubber mats on runningboard.
629 Tonneau steps.
630 Tonneau step brackets.
631 Rubber mat for tool box.
632 Battery box.
633 Tool box.
634 Dash brackets.
635 Rear locker box.
636 Tail lamp bracket, brass plated.
637 Front lamp brackets, brass plated.
638 Right hand side lamp bracket, brass plated.
639 Left hand side lamp bracket, brass plated.
640 Wood dash.

641 Aluminum dash shield.
642 Foot pedal bracket.
643 Shaft through foot pedals.
644 Brake foot pedal.
645 Clutch foot pedal.
646 Throttle pedal.
647 Tapered washers between clutch, brake and throttle pedal.
648 Square tube under dash.
649 Aluminum clutch with leather and springs under leather.
650 Leather on clutch.
651 Springs under clutch.
652 Clutch hub.
653 Clutch hub sleeve.
654 Ball thrust bearing back of slide.
655 Clutch slide.
656 Clutch yoke.
657 Special cap screws for clutch yoke.
658 Clutch shaft.
659 Clutch coupling.
660 Clutch coupling sliding squares.
661 Clutch coupling bolt (long).
662 Clutch coupling bolt (short).
663 Large spiral spring in clutch hub.
664 Large hexagon head cap screw holding spiral spring in clutch hub. (Clutch stud.)
665 Tapered pin and nut inside of clutch stud.
666 Thrust ball bearing and two washers on clutch screw.
667 Clutch buffer complete with leather covered button.
668 Clutch buffer brace.
669 Clutch buffer button.
670 Hexagon nut holding steering wheel on stem.
671 Steering chuck.
672 Steering stem with throttle and spark rods and worms.

673 Steering post with knurled nut at top.
674 Spark collar.
675 Throttle collar.
676 Steering wheel with ratchet.
677 Ratchet and screws for steering wheel
678 Spark lever on wheel.
679 Throttle lever on wheel.
680 Nut holding spark lever to rod.
681 Dust tube on steering chuck.
682 Dust tube packing nut.
683 Spark bell crank lever.
684 Bracket for spark bell crank lever.
685 Timer rod.
686 Throttle shaft with levers and throttle cam.
687 Throttle shaft brackets.
688 Rod and adjuster to throttle pedal.
689 Carbureter rod and adjuster.
690 Carbureter.
691 Carbureter intake pipe with flange.
692 Pipe nipple for carbureter.
693 Carbureter air pipe.
694 Auxiliary air inlet for carbureter.
695 Brake hand lever.
696 Brake hand lever slide.
697 Special screws in brake hand lever slide.
698 Controller hand lever.
699 Controller hand lever catch.
700 Grips for controller and brake hand lever.
701 Tension rods and ends for controller and hand brake levers.
702 Brake lever shaft with intermediate brake lever.
703 Controller lever shaft.
704 Short gear shifting lever.
705 Spiral springs for hand brake and controller lever rods.
706 Bell crank clutch lever.
707 Brass hexagon nut for controller shaft.



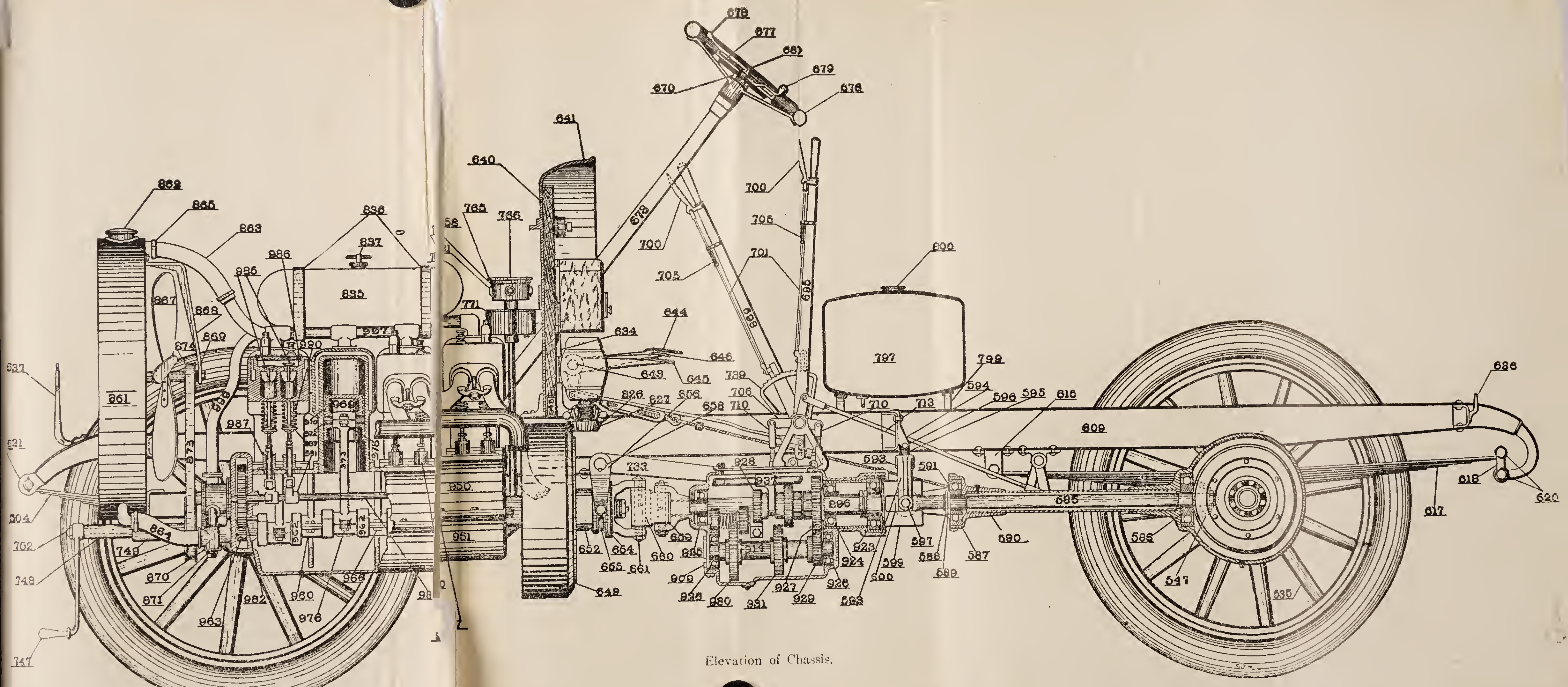
Transmission Gear.

708 Collar for controller shaft.
709 Brake and clutch slotted clevises with adjusting ends.
710 Adjusting ends for all brake rods and for brake and clutch slotted clevises.
711 Slotted clevises.
712 Clutch tension rod.
713 Long tension rod for hub brakes.
717 Left outside brake tubing, with levers and offset levers and bracket and muffler support.
718 Right outside brake tubing, with levers and offset levers and bracket.
719 Inside shaft with lever and offset levers.
720 Equalizing levers on outside shaft for large brake.
721 Cross bar on equalizing links.
722 Springs for equalizing levers.
723 Chain for equalizing levers.
724 Equalizing link rods.
725 Tension rods for large brake.
726 Tension rods for small brake.
727 Offset levers for large brake.
728 Offset levers for small brake.
729 Levers on inside shaft for small brake.
731 Interlocking sector.
732 Interlocking sector, roller and adjuster.
733 Long clutch lever.
734 Hub brake cable with clevis.
735 Turnbuckle for brake cable.
736 Double clamp for foot brake cable.
737 Clamp and leather for foot brake cable.
738 Position holder for foot brake.
739 Ratchet bracket.
740 Inside bracket for controller shaft.
742 Dust pan under transmission.
743 Right side dust pan on side of engine, rear section.

744 Right side dust pan on side of engine, front section.
745 Left side dust pan on side of engine.
746 Front dust pan.
747 Starting crank.
748 Starting shaft.
749 Starting shaft bracket.
750 Starting shaft spring.
751 Ratchet collar for starting shaft.
752 Brass plated nut for starting shaft.
753 Steering chuck brace.
754 Steering post bushing.
755 Worm and shaft for spark lever inside steering post.
756 Worm and tubing for throttle lever inside steering post.
758 Timer complete.
759 Timer and top of governor case.
760 Timer plunger spring.
761 Timer plunger holder.
762 Timer case.
763 Timer case and top of governor case.
764 Timer contact segments.
765 Timer screw cap.
766 Timer glass.
767 Fiber ring in timer.
768 Ball cup in timer.
769 Cone in timer.
770 Nuts on shaft through timer.
771 Governor case.
772 Governor upper spider and screws.
773 Governor lower spider and studs.
774 Governor weight pivot.
775 Governor shaft.
776 Governor arms and pins.
777 Governor weights.
778 Governor springs.

779 Bronze bushing in timer.
780 Long spiral spring holding timer.
781 Insulated bushings for timer case.
784 Muffler.
785 Muffler pipe.
786 Union nut for muffler pipe.
787 Muffler cutout valve.
788 Rear end of muffler complete.
789 Muffler spiral springs.
790 Muffler cutout lever.
791 Muffler cable.
792 Muffler push rod.
793 Muffler bell crank.
794 Muffler plunger.
795 Muffler bell crank stud.
796 Rubber button on muffler rod plunger.
797 Gasoline tank under front seat.
798 Gasoline tank straps.
799 Gasoline tank supports.
800 Gasoline tank cap.
802 Fiber block on dash for wiring.
803 Fiber block (4 hole) on engine for wiring, with support.
804 Fiber block (2 hole) on engine for wiring, with support.
805 Fiber block (6 hole) on engine for wiring, with support.
806 Fiber tubing for wiring.
807 Chains and rubber tubing for wiring.
808 Spark plug gaps.
809 Spark coils.
810 Vibrators for spark coils.
811 Adjusting screws for vibrator for spark coils.
812 Plug for spark coil.
813 Dry cells.
814 Terminal nuts for dry cells.
815 Wire connectors for dry cells.

816 Storage batteries.
817 Snap switch for dynamo.
818 Automatic cutout.
819 Snap switch for lights.
820 Electric light globes for side and tail lamps.
821 Dynamo.
822 Brush holders for dynamo.
823 Carbon brushes.
824 Coil nuts for coil connectors.
825 Sockets for side and tail lamps.
826 Dynamo governor with spring.
827 Dynamo rawhide pulley.
828 Bronze bearing bushing, lower end.
829 Wiring shield on front of dash.
830 Clevis pins, long.
831 Clevis pins, short.
832 Clevis pins for spark and throttle.
833 Compression relief rod.
835 Oil tank.
836 Oil tank strap.
837 Oil tank cap.
838 Pet cock on oil tank.
839 Oiler with case complete.
840 Oil pump pulley on oiler.
841 Flexible tube to oiler.
842 Stop cock to oiler.
843 Caps for adjusting stems on oiler.
844 Sight feeds on dash.
845 Glasses for sight feeds.
846 Plungers for sight feeds.
847 Plunger springs for sight feeds.
848 Pipes from oiler to sight feeds.
849 Pipe to engine crank case, long.
850 Pipe to engine crank case, short.
851 Pipe to engine main bearing.
852 Pipe to clutch slide.
853 Pipe to transmission.



Elevation of Chassis.

854 Pipe to rear system.
855 Unions for ends of oil pipes.
856 Oil packing nut at pulley.
857 Pipe to center of cylinder crank case.
858 Bracket for oiler.
859 Belt for oiler one-fourth inch diameter.
860 Belt hooks for oil belt.
861 Radiator.
862 Radiator filling cap.
863 Top hose for radiator.
864 Bottom hose for radiator.
865 Clamps on hose.
866 Hose nipple.
867 Radiator fan.
868 Radiator fan braces.
869 Radiator fan bearings with shaft.
870 Tee in bottom of pump.
871 Plug in tee in bottom of pump.
872 Drain cock in bottom of radiator.
873 Fan belt.
874 Fan pulley attached to fan.
875 Hood.
876 Hood fasteners with springs.
877 Radiator brace, right.
878 Radiator brace, left.
879 Fan pulley on crank shaft.
880 Auxiliary gasoline tank.
881 Front bracket for auxiliary gasoline tank.
882 Rear bracket for auxiliary gasoline tank.
883 Pipe from main to auxiliary gasoline tank.
884 Pipe from auxiliary tank to carbureter.
885 Pet cock on bottom of gasoline tank.
886 Stop cock on bottom of gasoline tank.
887 Air pipe from auxiliary gasoline tank.
888 Cap on air pipe on dash.
889 Oiler pulley on crank shaft.
890 Transmission complete with universal joint and coupling.

891 Transmission case complete with cap for reverse bearing.
892 Rear main bearing sleeve complete with universal joint, stationary tooth clutch, gear and annular bearings with adjuster.
893 Rear main bearing sleeve.
894 Lid for top of case.
895 Winged nut for lid.
896 Stationary tooth clutch.
897 Bushing for stationary tooth clutch.
898 End adjuster ring for rear main bearing.
899 Locking keys for end adjusters for main bearing and counter shaft.
900 Fillister head screws for locking keys.
901 Stud holding annular bearing on stationary tooth clutch.
902 Felt washer in long bearing end.
903 Large felt washer for short bearing end.
904 Small felt washer for short bearing end.
905 Main shaft.
906 Collar on main shaft between annular and clutch coupling yoke.
907 Counter shaft complete with gears.
908 Counter shaft bearing sleeve.
909 Adjuster for counter shaft.
910 Collar between 18 and 28 tooth gears on counter shaft.
911 Collar between 28 and 34 tooth gears on counter shaft.
912 Collar between 18 tooth gear and annular bearing on counter shaft.
913 Collar between 34 tooth gear and annular bearing on counter shaft.
914 Counter shaft.
915 Reverse shaft.
916 Reverse shaft spring.
917 Reverse bearing bushing.
918 Reverse bearing plug for front end.

919 Reverse bearing cap.
920 Guard for sliding reverse pinion.
921 Five-sixteenths inch dowel pin.
922 Plug in bottom of case.
923 Large rear annular bearing on universal joint in long bearing sleeve.
924 Small annular bearing in long bearing sleeve.
925 Annular bearing on main shaft, in front of case.
926 Annular bearings on counter shaft.
927 33-tooth gear on stationary tooth clutch.
928 Sliding pinion and clutch on main shaft with 23 and 17-tooth gears.
929 18-tooth gear on counter shaft.
930 34-tooth gear on counter shaft.
931 28-tooth gear on counter shaft.
932 14-tooth gear on reverse shaft.
933 19-tooth gear on reverse shaft.
934 Tubing for shifter rod.
935 Stuffing box for shifter rod.
936 Shifter rod.
937 Sliding pinion yoke.
938 Pinion shifter connecting rod.
939 Pinion shifter connecting rod end adjuster.
940 One-half-inch studs for main bearing.
941 Clutch coupling yoke.
950 Upper crank case of engine.
951 Lower crank case of engine.
952 Crank bronze bushing flywheel end.
953 Crank bronze bushing gear end (short).
954 Crank bronze bushing gear end (long).
955 Long bearing cap flywheel end.
956 Short bearing cap gear end.
959 Crank bronze bushing under hangers.
960 Hanger bearing caps.
962 Crank shaft.
963 Crank shaft gear.
964 Cylinders.
965 Loose gear cover for pump and cam gears.

966 Hanger bearing studs.
967 Timer bracket on cylinder.
968 Copper liners for connecting rods.
969 Pistons.
970 Piston rings.
971 Piston pin set screws.
972 Piston pins.
973 Connecting rods.
974 Connecting rod bushing, upper end.
975 Connecting rod bushing, lower end.
976 Connecting rod studs, lower end.
977 Connecting rod stud nuts, lower end.
978 Connecting rod stud, upper end.
979 Connecting rod stud nuts, upper end.
980 Cam shaft.
981 Cams.
982 Cam shaft gear.
983 Cam shaft bushings.
984 Cam shaft bushing cap.
985 Valves, both intake and exhaust.
986 Valve caps.
987 Valve lifter cages.
988 Valve lifters assembled.
989 Valve spring washers.
990 Valve springs.
991 Valve spring washer keys.
992 Spiral gears ⅞ in. bore.
993 Spiral gears ⅝ in. bore.
994 Inlet flange connection to carbureter.
995 Loose inlet flange.
996 Double tapered nipples for inlet and exhaust pipes.
997 Water pipe, horizontal outlet to radiator.
998 Water pipes, horizontal inlet.
999 Vertical water pipe.
1000 Waterpipe gaskets.
1001 Water pipe studs and nuts.
1002 Exhaust pipe, cast iron.

1003 Exhaust pipe, front section; exhaust pipe, rear section.
1004 Clamping bars for exhaust and inlet pipes.
1005 Inlet pipe cast iron.
1006 Inspection plates.
1007 Inspection plate screws.
1008 Flywheel.
1009 Flywheel countersunk bolts for attaching flywheel to crank flange.
1010 Flywheel hexagon bolts for attaching flywheel to crank flange.
1011 Flywheel bolt nuts.
1012 Gear pump complete.
1013 Pump case.
1014 Pump case cover.
1015 Pump gears.
1016 Pump gear shaft, long.
1017 Pump gear shaft, short.
1018 Pump packing nut.
1019 Pump packing gland.
1020 Relief cocks, ¼ in.
1021 Drain cocks, ⅛ in.
1022 Priming cups.
1023 Spark plugs.
1024 Spiral gear shaft collar on upper end.
1025 Spiral gear cover.
1026 Spiral gear timer shaft.
1027 Spiral gear shaft, lower bushing.
1028 Spiral gear shaft, upper bushing.
1029 Crank case vent.